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AUTOMOBILE TROUBLES AND REPAIRS WELDING-VULCANIZING

A Practical Guide to Proper Methods of Driving,
Solving Road Troubles, and Making Repairs,
Including Tire Vulcanizing and
Autogenous Welding

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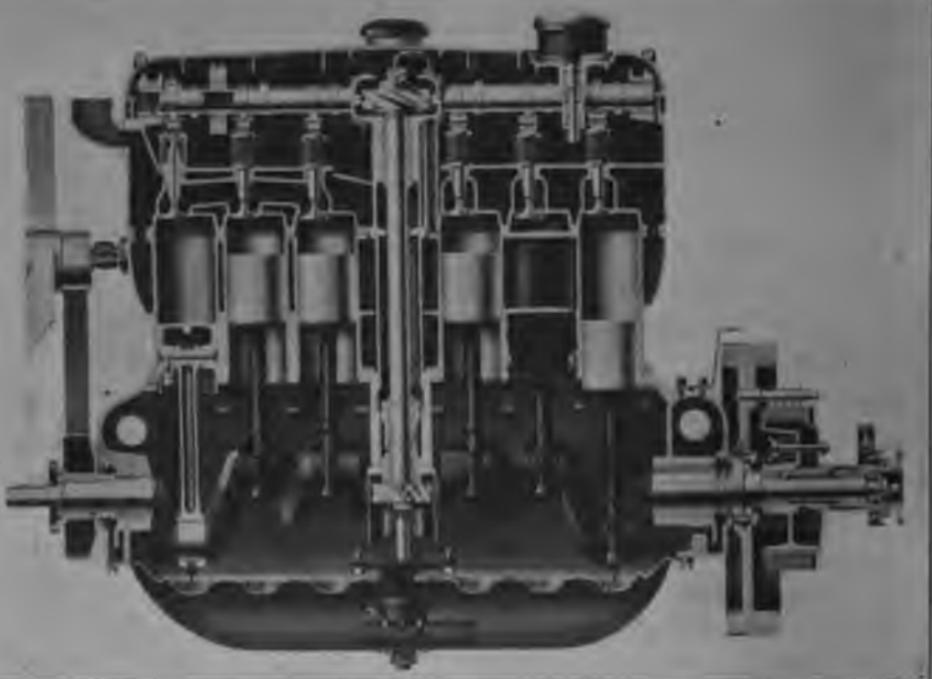
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INTRODUCTION

THE modern automobile is mechanically a fine piece of engineering but notwithstanding its perfection it is bound to break down unless it is well run and kept in repair. The simple driving operation is one of the easiest things to acquire but there is an astonishing number of things which an inexperienced driver will do and continue doing which not only interfere with the smooth running of the car but cut down its efficiency as well. The acquiring of these kinks by casual reading will often avoid some bitter experiences and save an accident or two. As to general repairs, every owner must settle for himself whether he will shunt his car and his troubles to the garage repairman or save time and expense and make himself more independent by learning to solve his own difficulties.

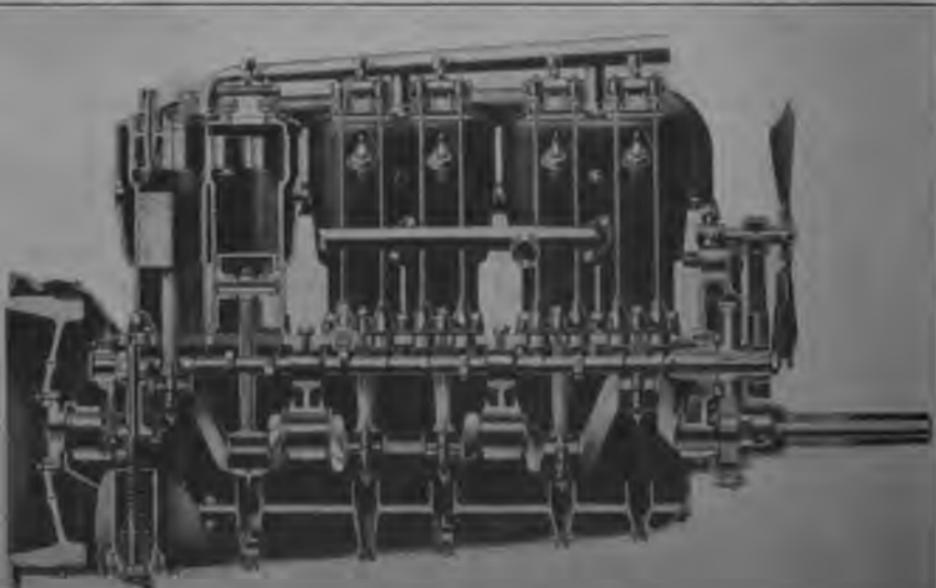
¶This volume is designed for the owner, or the driver, who wishes to properly take care of his car, and for the repairman who is anxious to broaden his own experience. Part II covers a multitude of helpful repair suggestions for all parts of the car from the engine to the differential, from the steering gear to the tires. The section on tire vulcanizing with the description of proper tire repair methods will be found especially helpful. In Part III is given an excellent article on welding as applied to the repair shop. The increasing use of this handy method of making difficult repairs gives this section special interest. The cost data will be found exceptionally valuable.

¶It is the hope of the publishers that the suggestions given will be found pertinent and helpful.



CHALMERS SIX-40 MOTOR WITH OVERHEAD CAMSHAFT

Courtesy of Chalmers Motor Company, Detroit, Michigan



SECTION OF BUICK, SIX-CYLINDER MOTOR

Compare with the motor shown above. Both have the valves in the head but in the Chalmers the camshaft is overhead, and in the Buick it is alongside the crankshaft.

Courtesy of Buick Motor Company, Flint, Michigan

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Part III

WELDING IN AUTOMOBILE REPAIR SHOPS

CRAVENS

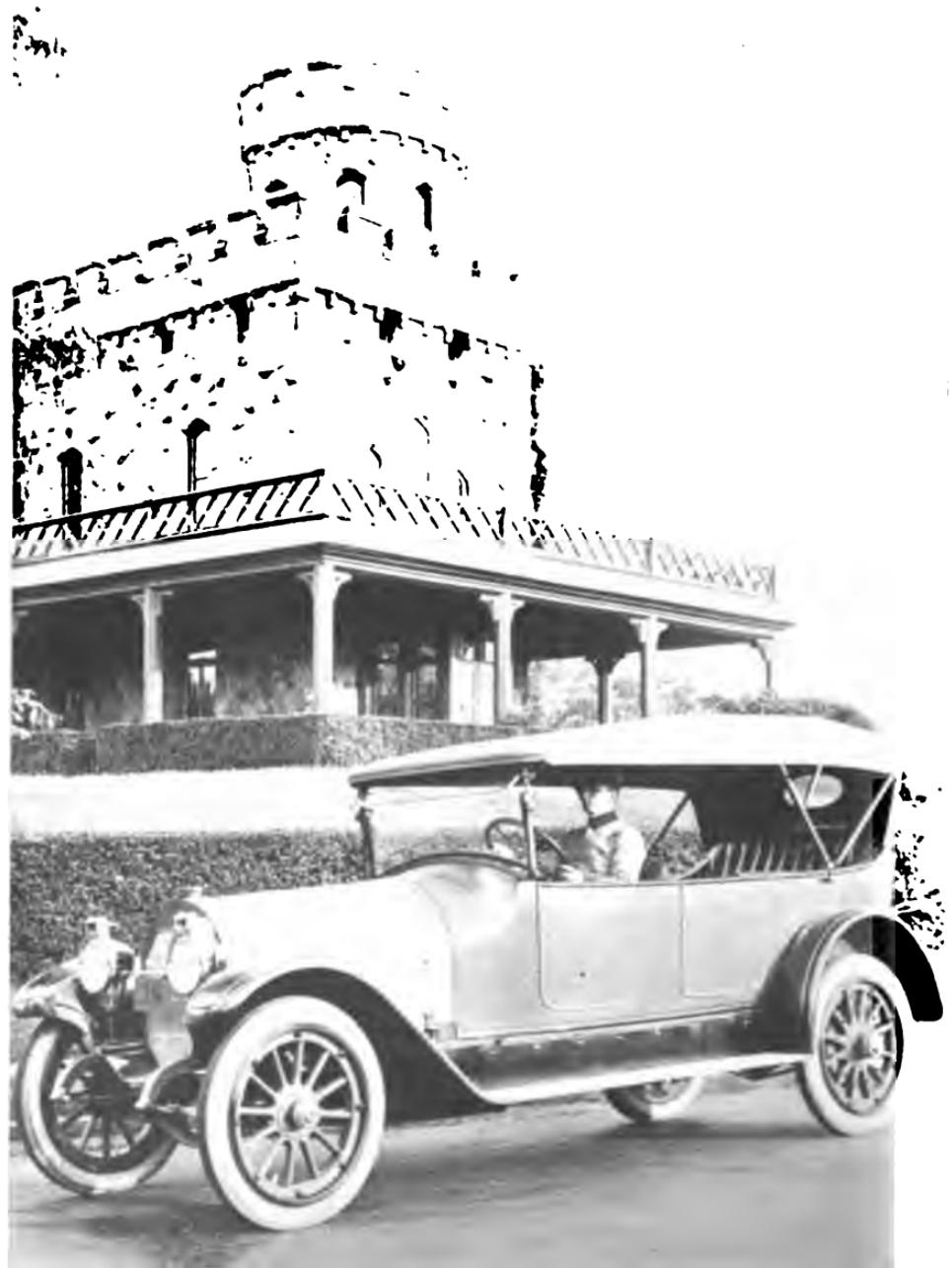
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LOCOMOBILE "38" SIX-PASSENGER TOURING CAR
Courtesy of the Locomobile Company of America, Bridgeport, Connecticut

AUTOMOBILE DRIVING

PART I

MANAGEMENT ON THE ROAD

First get your car, then learn to use it. This homely phrase based on another one equally homely and of daily use, sums up in a few words the matter of learning to drive a car. After the car has been duly purchased, the glib salesman will show one in about four minutes how to drive. Yet after all this assistance, it will take almost any man of fair intelligence a whole week or more to learn to run the car alone and with confidence, while he will continue to learn additional points as long as he continues to drive. Although the gasoline engine, in combination with the other mechanical parts of the ordinary touring car, is not so very complex when tackled in a common-sense manner, there are so many things which enter into the whole makeup and which may vary, either singly or in combination with others, that the combinations are practically infinite.

STOPPING THE CAR

Of premier importance is starting, and the proper way to go about it. But even before this is done, the beginner should learn to *stop* the car, for accidents often happen from inability to stop; never from inability to start. So, the first thing on the novice's program should be the matter of stopping.

Closing the Throttle. Without a doubt, the surest way to stop the car, one that is always effective, and by all odds, the first one for a beginner to learn is that of shutting off the *throttle*. This he must learn at once and before he learns anything else; it should be so thoroughly grounded and fixed in his mind that no matter what sort of a discomfiting situation he finds himself in, he will always think to shut off the throttle. This is effective, in that with the throttle closed, no gas can reach the engine, which, therefore, cannot run. If no gas be supplied and the engine cannot run, its own internal resistance, to be explained more in detail later, will stop the car very quickly, though not immediately. Other methods will stop the car

more quickly, but the novice might release them accidentally before the source of trouble was removed, making the situation as bad as, if not worse than, before. With the throttle closed, the engine stops and with it, of course, the car.

Fig. 1 shows how this is accomplished. Nearly every car has the spark control and the throttle placed upon the steering wheel, so as to be convenient. Practice varies whether the spark is placed above or below the throttle, but in any case, it is an easy matter to ascertain. This is done by lifting the *hood*, or *bonnet* as it is variously

called, so as to expose the mechanism. Then any movement of a lever on the hand wheel moves either a part of the ignition apparatus or some portion of the carbureter. If the latter, the lever moved is then the throttle lever.

It is not necessary to remember which movement of the throttle turns the mixture on or off, since, if the car is running, it must of a necessity be turned on; and to stop,

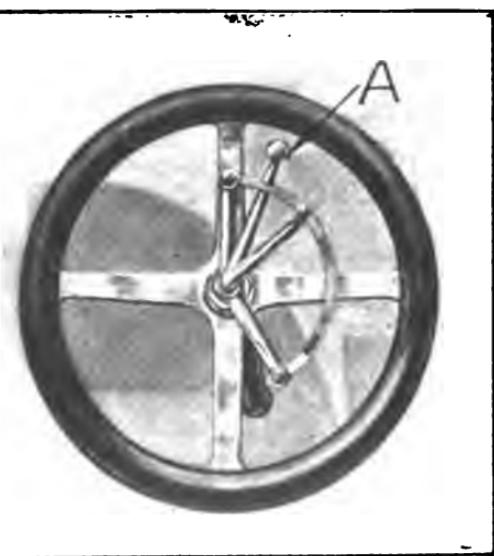


Fig. 1. Typical Steering Wheel.

it is only necessary to move it as far as possible in the opposite direction. In Fig. 1, the longer and more easily operated lever, marked *A*, is the throttle lever, and is shown in the "off" position. In the "on," or open position, this is at the side, where it is more convenient to the hands, which should always grasp the wheel at two points directly across the rim of the wheel from one another, *i. e.*, 180 degrees apart. The ordinary application of levers is such that in this position, the location of the spark and throttle levers will bring them down close to the right hand; in which location, they may be operated without removing the hand from the wheel, a slight movement of the thumb or one finger being sufficient. For the "off" position, on the contrary, it is necessary to remove the

hand from the wheel and reach for the levers, either to put them both in the "on" position or both on the "off" location.

When the danger or source of trouble is fully removed, it is the work of a second to get out and start the engine again. This method of stopping the car by shutting off the engine, the beginner must learn at once and remember for all time, although later on, with more skill in handling the car, and increased presence of mind, the other and superior methods will doubtless be used in preference. This one has the merit, for the beginner, of removing for a considerable length of time all possibility of future danger, and only recurring of the novice driver's own volition. That is, there can only be additional danger when the engine is deliberately started again.

Emergency Brakes. Other ways of stopping the car are numerous, as stated before, but to mention them in order of merit, the best is a combination of the method just mentioned with the application of the *emergency brakes*. The latter are placed on the car, as their name would indicate, for the express purpose of stopping the car in an emergency. Usually they consist of a pair of very large and powerful brakes fixed directly to the rear wheels and operated by the outer of the two hand levers. These hand levers may act forward or backward, *i. e.*, they may be applied by a pull or a push. The method to be used will depend upon the specific car in question, since the makers differ as to this and the system of operation has never been wholly standardized.

Two figures are given to show this. Fig. 2 is that of a popular car on which the lever *pulls back* to apply the emergency brakes.

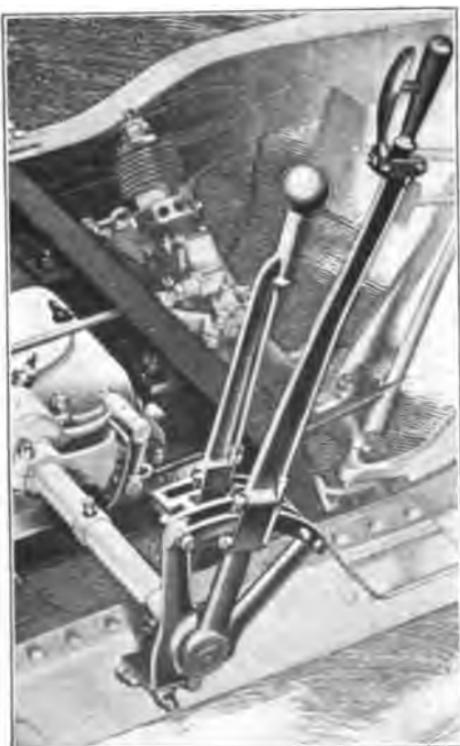


Fig. 2. Typical Side Levers of Gasoline Car

The right-hand lever is for the brakes. These levers are those used on the Pierce-Arrow car, one of the few right-hand-drive cars, the levers being inside the body. Fig. 3 shows another car on which the emergency lever *A* pulls back, this being almost universal now. Fig. 29, however, shows one that pushes forward, a method used by some makers.

Service Brakes. All modern cars are equipped with a secondary set of brakes, which are known as the *service brakes*, and are applied

by means of a foot pedal. While this has not been standardized any more than the action or placing of the emergency brake levers, it happens that the majority of car builders utilize the right-foot pedal for this purpose, Fig. 4. This operates a second set of brakes upon the rear wheels of a shaft-driven car, according to the latest practice, or upon the countershafts of a chain-driven car. It is sometimes a single, wide-faced brake placed upon the main shaft just back of the transmission. In any case, pressing the pedal *D*, Fig. 3 and Fig. 4, forward and down applies the secondary set of brakes.



Fig. 3. Control Group of Overland Four-Cylinder Car
Willys-Overland Company, Toledo, Ohio

These being applied by means of a foot pedal, while the emergency brakes are operated by means of a hand lever, makes it possible to apply both at once, with superior braking results. In the use of a *pull-back* emergency lever, it is possible to apply

the foot brake first, and with the leverage upon this as a brace, apply the emergency brakes more forcibly.

It must be remembered in the use of both of these, that the operator is simply using his strength and the increased leverage which the arrangement gives him, against the force of the engine, and that other conditions being the same, when the foot pedal and hand lever are removed or released, the engine will go on propelling the car just as fast as before the brakes were applied.

This makes it highly important for the new driver to learn either to pull his gear-shifting lever back or to push it forward, as the case may be, so as to bring it into the neutral position. When this is done, none of the gears are in mesh, and if the driver should involuntarily let the foot slip which is holding the clutch out, or that which is pressing down on the brake pedal, no harm will be done. In this way, shifting into neutral may be considered as an example of the "safety first" method of driving, although it may mean shifting several times, as well as a short delay caused by starting with low gear, working up to second, and then to high. This safety method is of especial importance to beginners, as the expert driver, in a tight situation, will not become confused or let the foot slip off, whereas the beginner may.

Using the Engine as a Brake. A fourth method, and one which takes care of the case just mentioned, is that of throwing off the spark. This is brought about by means of the spark advance lever on the hand wheel previously spoken of, and shown at *C* in Fig. 3.



Fig. 4. Service Brake and Operating Pedal on the Chalmers

Throwing off the spark prevents the ignition of the charge just drawn into the cylinder, or any succeeding charges, until the spark is again thrown on. This causes the engine to draw in gas, compress it, and eject it without receiving a power impulse. All this takes power; since none is supplied, the forward energy of the moving car is consumed in turning the engine over; this rapidly subtracts from the momentum of the car, and in that way soon brings it to rest. In the language of the automobile driver, this is the act of *using the engine as a brake*. Despite its effectiveness, the practice is to be deprecated because it is at the same time wasteful of fuel and is said to be hard on the engine, which, after all, is the vital, beating heart of any car, and should have corresponding care.

Changing Gears. The last method of snubbing the forward progress of the car consists of nothing more nor less than slowing down by shifting to the *low gear*, in which, as will be explained later on, many revolutions of the engine are necessary to make one rotation of the rear wheels. In conjunction with this, a retarded throttle will lower the movement of the car to a veritable crawl. This is usually very handy to know and to utilize in the crowded streets of large cities, particularly in the downtown districts during teaming hours.

Having then mastered the numerous ways of stopping and slowing the progress of the car, including the one to be most firmly impressed upon the mind—that of shutting off the gas supply by retarding the throttle lever to the limit—the amateur driver can begin to consider something else, which would naturally be the process of starting and the routine of inspection which precedes it.

STARTING THE CAR

Method. The best way to go about this is to have a simple routine, which is always followed. In order to always do the same thing and in the same order, it is well to have a list of things to be done, which should be learned and always followed. In a short time the driver will do these things unconsciously each time before starting out, and then the simple system will have served its purpose.

Now as a suggestion, one might say to oneself, what are my wants? and, after having attended to them, have I got everything? The key words to these two simple questions are the words WANTS and GOT. Taking these as the keywords, it is possible to lay down

all of the things that should be done before starting, so that every letter of these two words represents one thing, as follows:

W ater	G asoline
A cetylene (or lamps)	O il
N uts and bolts	T rying out
Tires	
S park retarded	

Water. From the above, water stands for the question, is the water cooling system completely filled, or does it need any more water?

Acetylene. Then comes the question of proper lights—is there sufficient fuel to light the car on its way, whether it be acetylene compressed into tanks, generated from carbide, or just plain oil; or in the modern electric method is the lighting system complete.

If a gas tank is used instead of a generator, the autoist should see that the pressure gauge indicates that there is sufficient gas in the tank for the trip, and, if not, the tank should be replaced by a charged one.

In connection with filling the lamps it would be well to form the habit of wiping the tail-lamp glasses and the license-plate with a cloth, as these are usually neglected and become obscured by dirt, and may subject the autoist to arrest for not having a rear light or a legible license-plate.

Nuts and Bolts. Next, it is wise to glance over the more important bolts and nuts to see if they are tight, or at least appear tight. At first it is well to go over them with a wrench, but later on this is unnecessary.

Tires. Now the tires represent a very important part of the car, one that is very expensive to buy and maintain, so that it is a good idea to get into the habit of glancing at all four tires before setting out on any kind of a journey. In particular, the inflation should be examined. Tire manufacturers say that 35 per cent of tire troubles are due to under-inflation. In this connection, the table of tire pressures, Table I, will be very useful. It may be used in connection with any kind of a tire-pressure gauge. There are a number of these gauges on the market, and the beginner should obtain one very early in his driving career, learning to use and rely on it.

TABLE I
Proper Pressures in Tires

SIZE OF TIRE	PRESSURE RECOMMENDED		WEIGHT PER WHEEL	
	FRONT	REAR	FRONT	REAR
28 by 2½	40	45	225	275
30 by 2½	45	50	225	275
28 by 3	48	52	350	425
30 by 3	50	55	375	450
32 by 3	52	58	375	450
34 by 3	52	60	400	500
28 by 3½	55	63	400	500
30 by 3½	58	65	450	550
32 by 3½	60	65	500	625
34 by 3½	63	65	550	675
36 by 3½	63	68	600	750
30 by 4	63	68	550	650
32 by 4	65	70	650	800
34 by 4	68	70	700	875
36 by 4	68	72	750	900
32 by 4½	68	72	700	800
34 by 4½	70	75	900	1125
36 by 4½	72	78	1000	1250
34 by 5	75	80	1000	1300
36 by 5	80	90	1150	1375
38 by 5	85	100	1250	1500
36 by 5½	90	105	1400	1600
38 by 5½	95	110	1500	1700

Spark. To save his own body, or to be more specific, his arms and shoulders, the driver must retard the spark every time before attempting to start the engine, else a back kick will result and injury will surely follow. This is an important point and one that, like shutting off the gas in an emergency, should be memorized early. The importance of this may be judged from the statement, borne out by the reports of insurance companies, that 37 per cent of all automobile accidents to either driver or passenger are cranking accidents.

Gasoline. Surely, the engine has not yet been invented which will run without fuel, so it is of primary importance to have not only some fuel, but enough to complete the proposed journey. This then stands for the question, "Is the gasoline tank filled?"

Oil. Lubrication is of equal if not superior importance, for even if everything is right and ready to run, with plenty of fuel, to run it without lubrication is to run it for the last time, *i. e.*, a lack of lubricant (oil, grease, graphite) will ruin the finest machinery.

After having started the motor, the autoist should listen for any unusual sounds while it is running, and closely watch the sight-feeds on the lubricator, adjusting them if necessary.

Trying Out the Car. After starting the engine the autoist should take his seat, and, withdrawing the clutch, place the shifter lever in the position for first speed, release the brakes, and start the car by engaging the clutch gradually.

While the car is moving the brakes should be operated, first the hand brake and then the foot brake, and if any adjustments are needed they should be made at once. A trial of the brakes with the car running is more valuable than a number of trials with the car at rest.

If the gear-shifter lever does not work properly, or the clutch slips, the fact will be indicated, and adjustments can be made on the spot, saving the autoist trouble and humiliation on the road.

Things to Remember About Starting. Next to the points covered above, the most important thing for the beginner to learn is the proper method of starting an engine, and of holding the starting crank so as to render the process a safe one. These are very hard things to impress upon the novice, who thinks that starting consists of turning the crank—a very simple operation—until the engine responds and starts. This is very far from the real situation.

Method of Cranking. The proper and safe method of starting should be learned for there are methods in daily use which are not safe. Take, for instance, the ordinary way of cranking the motor. Most motors turn clockwise, that is, from left to right. Then, in starting, the ordinary driver, who has just "picked up" driving, grabs the crank with the *right hand* and pulls on it until the top is reached, then pushes it over the center, and the motor either does or does not start. In the latter case, he continues to pull it around. This method, whether right or wrong, may possibly work on a small engine, but wait until this plan is tried upon a large motor.

The driver, to crank in this fashion, must stand at the left and between the center of the car and the wheel or fender. At the top of the stroke, which is also the top of the circle of revolution of the crank, he is in a very awkward position. Worst of all, his arm is extended stiff, and a back kick will operate directly against it, as shown at the left in Fig. 5, and shown also in Fig. 6. In this

manner the arm is liable to be broken, or at least badly wrenched. In addition, the awkward position is such that the weight must be concentrated upon the right foot in order to balance. The least tendency toward back-firing is liable to destroy this balance, so that the driver may fall over. The writer has seen men start a car in this fashion, and, finding the engine turn over more readily than they had expected and provided for, the very effort of starting was sufficient to upset their balance and cause them to fall over.

With *left-hand* starting, however, these three objections are obviated. As the turn of the crank is away from the center of the car, its movement may be counted upon to give the driver more room in which to stand. Instead of the last and hardest part of the

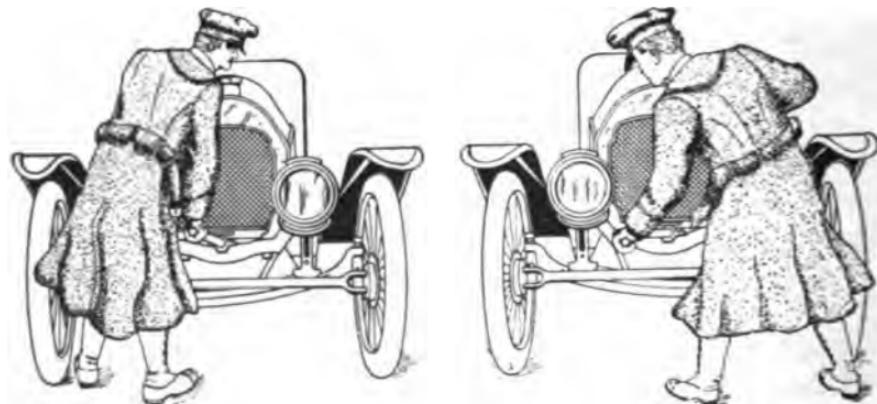


Fig. 5. Wrong and Right Method of Starting

cranking being in the nature of a push with the arms stiffened, it is more of a pull with the elbow flexed, and therefore free, as shown at the right in Fig. 5. If the engine back-fires it is easier to let go of the spinning crank, because it is exerting a pull on the hand, not a push as before. Then, too, the substitution of a well-balanced position for an awkward one helps to make the action of freeing the crank so as to let it turn freely, much easier. The advantages of left-hand starting, then, may be summed up as follows: less danger to the operator's arm, easier balance of the body, and less work.

How to Hold the Starting Crank. In the apparently simple operation of cranking an automobile engine there are many little points for the novice to consider. Among these the most important are those which make for increased safety. Thus the seemingly

elementary action of grasping the crank handle is susceptible of two methods—one, right and safe; the other, not safe, and therefore, not right.

Ordinarily the driver will grasp the handle with a firm grip about as he would grasp a baseball bat; that is, with the fingers wrapped around it in one direction and the thumb around it in the other, as shown at the right in Fig. 6. Whatever method of cranking is employed, this grip is wrong, for if the motor back-fires the position of the thumb prevents letting go, at least quickly enough to be of any service.

The proper way, as shown at the left in Fig. 6, is to take hold with the fingers around the handle, but loosely, never tightly. Then the thumb should not be used at all, but should be folded back along-

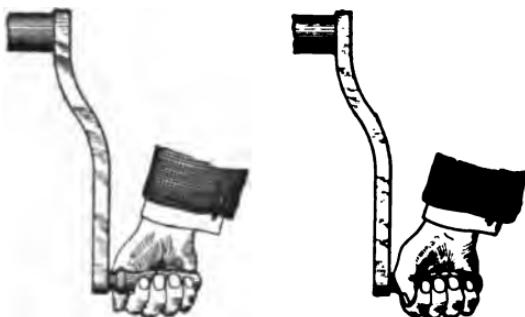


Fig. 6. Right and Wrong Crank Grip

side of the first finger and out of the way. The whole work is done by the fingers and, if anything happens, the backward action of the crank simply opens the closed fingers and no harm is done. This holds true particularly when taken in conjunction with left-hand starting. In that case, the latter and dangerous part of the starting action is a pull toward the operator. The arm in which the greatest strength can be exerted is in tension. So, if the engine back-fires, a person just stands still and holds the arm taut, while the backward action of the engine opens the fingers.

Starting Devices. In the last two or three years, the starter has been developed to a point where it may now be considered as extremely reliable. There are three general forms: the mechanical form which is low in price, simple in operation, and with a small number of parts; the air or gas form which has more parts, is more complicated, and

costs more; and the electric type which has the greatest number of parts, is the most complicated, and probably costs the most.

Mechanical Starters. A mechanical starter is really only a substitute for the crank, allowing the driver to do his cranking from the seat. That is, it is nothing but a mechanical transmission device by means of which the driver avoids going around to the front of the car and whirling the usual starting crank. Of this form, the Boston, Fig. 7, is typical, this being shown applied to a Ford car. As will be noted, a handle *A* projects from the front of the dashboard, this being connected by a rod and cable to a pulley, another portion of which carries a chain attached to another pulley on the usual starting shaft. By means of a pull-back spring, this is automatically restored to its normal position ready for use the next time. In addition, the large pulley carries a roller clutch so that, should the engine backfire, no damage will be done. There are other mechanical forms, one,

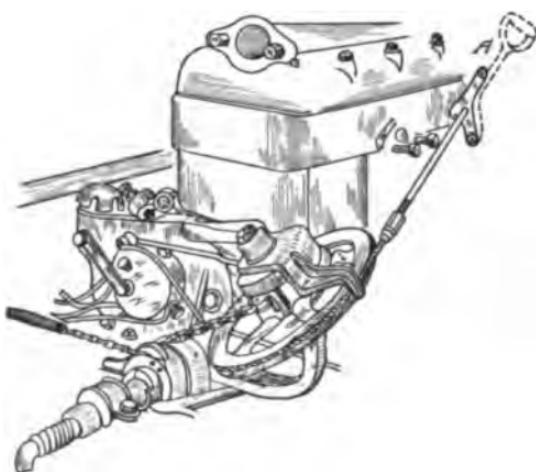


Fig. 7. Boston Mechanical Starter. Much Used on Small Cars

for instance, widely tried a few years ago, in which the engine was started by means of a large flat spring, the latter being automatically wound up by the engine after use. There are many other mechanical forms which differ from the one shown in minor details only.

Gas and Air Starters. After a number of more or less unsuccessful attempts to produce a satisfactory gas starter, this form has just been abandoned. In the light cheap cars such as Ford, Saxon, etc., the cost was too great to compete with the lower-priced electric starters. The same thing is true of air starters, which had the additional disadvantage of inefficiency, the average air compressor efficiency being about 15 per cent.

Electric Starters. Electric starting is now well-nigh universal, and judging from the manner in which it is being applied to all new

cars, even down below \$750 in price, it will be universal in a few years. Of course, it has been developed along several lines and there are dozens of different systems. In general, however, each system includes a rotary generator to produce the current when driven by the engine; a battery in which to store this current; a rotary motor to turn the engine over when current is supplied to it from the battery; and the necessary electrical switches, cut-outs, etc., to render the operation regular, precise, and safe.

In some systems, the units are combined as, for instance, but one rotary generator-motor being used, this acting as a generator at one time and as a motor at another. Also, it is possible to use some of these units for other purposes, such as ignition and electric lighting. These combinations have brought about the one-unit system, the two-unit system, and the three-unit system.

The one-unit system has a single member which is used for starting, lighting, and ignition; the two-unit system has a starting and lighting member and an ignition member in one form, or into a starting unit and a lighting and ignition unit in another. The three-unit system has separate units for each of these functions.

Whatever the arrangement or form, the electrical starting device allows of starting the motor by opening the throttle, setting the spark, and then pressing a button or pulling a lever. In some systems there is a switch, in the form of a handle, located on the dashboard. The switch is turned through an arc of about two inches, thus completing the ignition circuit and connecting the battery to the motor-generator. This automatically starts the latter running, which turns the engine over. In these systems, it might be men-



Fig. 8. Starting Lever on Hupmobile Cars Is Small,
Placed Alongside Other Levers
Hupp Motor Car Company, Detroit, Michigan

tioned, the motor-generator continues to run; and if for any reason the engine should slow down as when about to stall from overload, the electrical unit automatically changes over to a motor and assists in turning the engine over. For this reason, this particular arrangement is called semi-automatic, whereas it gives the result of a non-stallable motor—a very valuable feature.

In the system shown in Fig. 8, a small extra lever *A* is placed on the footboard near the shifting and brake levers. Starting is performed as follows: The ignition switch and throttle switch, also on the dashboard, are thrown to the starting position and the lever *A* is then pushed forward. As is outlined in Fig. 9, which shows the working parts of this system, this movement (to the dotted position) draws the lower end *N* of a lever arm backward

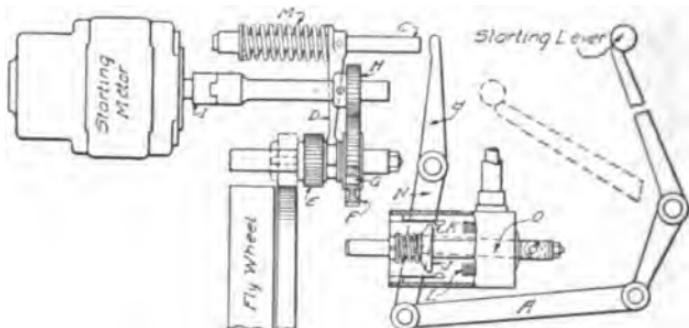


Fig. 9. Diagram Showing the Method of Operation of 1915 Hupmobile Starter

and in so doing makes an electrical connection in the starting switch so that current can flow from the battery to the motor. At the same time, the upper end of this lever *B* moves forward until it picks up the end of the shifting rod *C*, and continuing pushes this forward. In so doing it moves the arm *D* and with it the gear *E* until the latter meshes with the gear teeth cut in the face of the flywheel. Then the starting motor is in the position of receiving electric current from the battery, and of being mechanically connected with the engine through the shaft *I* carrying gear *H*, which meshes with gear *F* and on this latter's shaft, the gear *E* in mesh with the flywheel. That being the case, when it rotates, the engine is turned over. And all this results from pushing forward the small lever shown in Fig. 9. This is a three-unit system.

In the Locomobile, of which Fig. 10 shows a view of the dash-

board, the work of making the electrical connection and the mechanical action of shifting a gear, as described previously for the



Fig. 10. Dashboard of Locomobile, Which Starts with a Button
Courtesy of Locomobile Company of America, Bridgeport, Connecticut

Hupmobile and there done by means of a mechanically operated lever, is all performed electrically. Pressing a single button on the dashboard operates to shift the gear, make the electric connection, and start the car. This simplifies starting to its lowest terms.

In many systems, a heel button or pedal is used in place of the handle. On the Cole car, Fig. 11, this is placed at the right of the other pedals and slightly higher for operation by means of the toe. This is not always the case, for on the Overland car, shown in Fig. 3 and again in Fig. 19, the button is placed close to the seat and depressed by the heel.

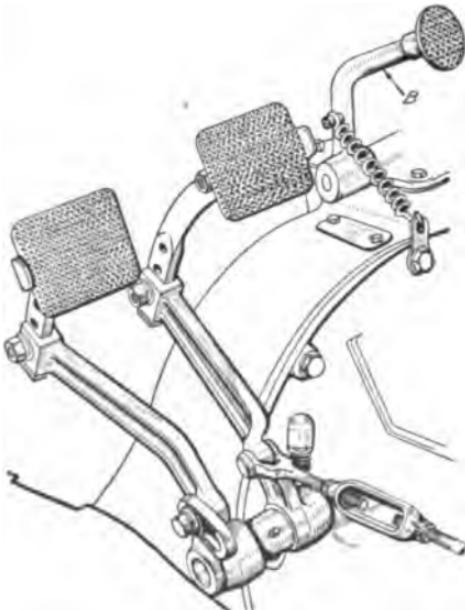


Fig. 11. Starting Pedal Used on Cole Cars,
Alongside Regular Pedals
Courtesy of Cole Motor Car Company
Indianapolis, Indiana

CONTROL

Typical Forms of Selectors. To master early the methods of control is easier to say than to do, as is shown plainly in Figs. 12 and 13. These depict the action of changing gears on a number of different American cars, and show at a glance the wide divergence in practice which the new driver must go up against. The upper figure is meant to represent the quadrants of cars having four-speed gears, and the lower figure, the quadrants of those cars fitted with three-speed gear boxes. By four speed and three speed, is meant, respectively, four forward speeds and three forward speeds; the reverse speeds, being taken for granted, are not counted in mentioning the number of speeds which the gear box affords. Thus, to call attention to a few of the types selected at random, *A*, Fig. 12—the quadrant on the former Lozier G—had the reverse on the outside and forward, while the high speed was also forward but inside. The low speed was outside and backward, while a forward movement of the lever in the same line gave second speed. To attain third speed, when in high, was simply a matter of pulling the lever straight back. In *C*, Fig. 12, are shown the various lever positions on the Studebaker car. Again the reverse is to be found on the outside and forward but there the resemblance ceases, for the high speed is outside and forward, as compared with inside and forward on the Lozier. Low speed is inside and forward as contrasted with the Lozier's outside and back. Second speed is found inside and at the back as against outside and forward on the Lozier, and similarly with third, which is outside and back, instead of inside and back. This would lead to much trouble at first, as for instance, when a person, who was used to a Lozier and was driving a Studebaker for the first time, was caught in an emergency, and dropped to reverse, desired to go into low, he would involuntarily go through the Lozier movement to which he was accustomed, namely, outside and back. This done upon the Studebaker results in third speed, which is very high as compared with the expected low. Sequel, an accident. Of course, this could only happen during the first few weeks of use of a new car, as after that time in any situation, it would be a matter of doing the shifting according to the quadrant of the new car. But to prevent just such a happening, the control should be mastered thoroughly, and learned so that one can repeat upon request, the various speeds and the

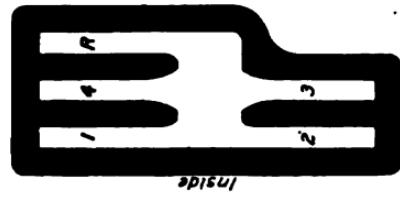
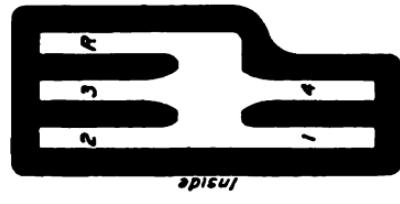
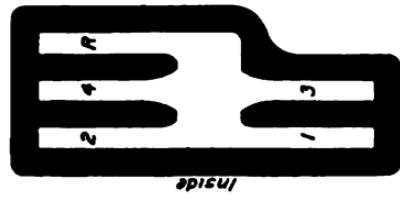


Fig. 12. Variation in Typical Four-Speed Selectors on American Cars.

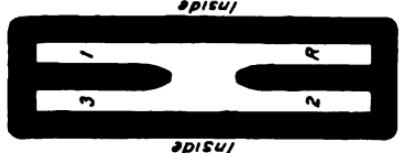
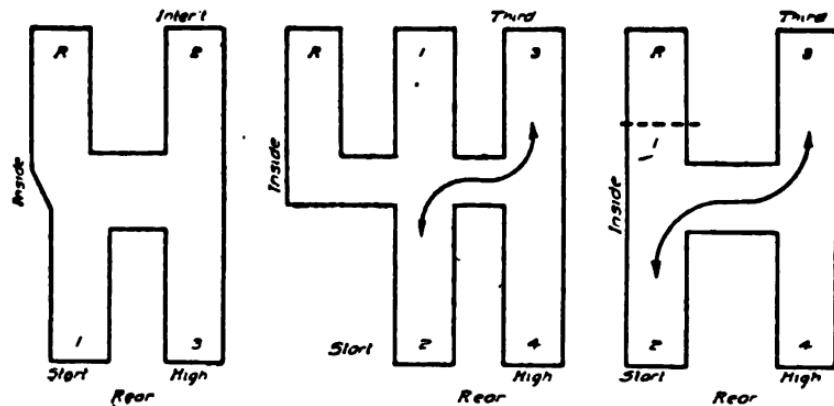


Fig. 13. Variation in Typical Three-Speed Selectors as Used on American Cars.

corresponding positions. Changing gears is at once a peculiar and a complicated action, for the clutch must be thrown out for an instant, during which the levers are shifted, after which the clutch is gently let in again.

Possible Standardization. This peculiarly mixed and at the same time dangerous situation is in a fair way to be cleared up by the standardization of the quadrants for American cars to a possible two or three, used on all cars. As early as June, 1911, the Society of Automobile Engineers considered and placed in their data books, the three suggested standards shown in Figs. 14, 15, and 16. These, which have since been adopted by a large number of American firms, are as follows: Fig. 16, suggestion for three-speed transmission;



Figs. 14, 15, 16. Three Standard Forms of Quadrant Gates Suggested by Society of Automobile Engineers

Fig. 15, suggestion for four-speed transmission, which it will be noted is the same as Fig. 14 but with the extra space for the additional speed, the low speed replacing the reverse and that being placed by itself off to the left side; and Fig. 16, suggestion for a four-speed gate, in which a latch is used to prevent accidental entrance to reverse, the same space being used for low and reverse (with this modification) so that the three-speed, Fig. 14, and the four-speed, Fig. 16, would be alike except for the latch.

Proper Procedure in Gear Changing. One thing that should be mastered early in the process of learning to change gears is that the motor and the car should be moving at corresponding rates of speed. That is, when it is desired to change down from a high to a lower speed, if the car be allowed to slow down a little before changing,

better results will be had. This may be effected by throwing the clutch out and holding it out for a short time, when the car will slow down a little. If this is done, the engine, being free for a time, will begin to race and so the changing process must be accompanied by a closing of the throttle to reduce the engine speed. Similarly, with changing from a low speed up to a higher one, the car should be moving rapidly, and the change should be made as quickly as is possible, so that the car does not lose any of its momentum. With the planetary type of gear, the matter of changing speeds is very simple, consisting of but a push on one or the other of two pedals, this action supplanting both clutch and change gear lever action on a sliding gear transmission. With this form, drivers usually guess at the proper period at which to make the change, any mistake in estimating the rates of the car and motor being of little consequence, as the bands will slip instead of transmitting the shock to the gear. A similar action occurs in the case of individual clutch or friction gears, but with the sliding type severe strains and shocks have to be taken up by the clutch and are usually transmitted in part to the gear if the clutch is not slipped. This applies to the other types as well.

Change Gears Quickly and Completely. One point which the novice should be careful of is in shifting gears. If the clutch is thrown in before the gears are meshed as far as they should be, they will have but a narrow contact of perhaps one-fourth inch. This continued will burr up and spoil both gears. In shifting, too, the novice must learn that the operation must be performed with exceeding quickness. The gears are both rotating sometimes, and one always. In order to mesh a stationary gear with a rotating one, even if it be rotating slowly, it is necessary to push the one gear into place as quickly as possible, doing this with one firm, continuous motion.

Changing from a Lower to a Higher Gear. In changing from a lower to a higher gear it will be necessary to speed up the motor by means of the throttle or accelerator in order to store enough energy in the flywheel to furnish the work needed to accelerate the car to its new speed. As the speed of the car increases the higher gear should be engaged, the autoist not being in too great a hurry to make the change; however, the movement of the change gear lever should be made quickly in order that the car does not lose way. When changing from a higher to a lower gear the change should be made so

quickly that the car has no time to slow down. When climbing a steep hill it should be ascended as far as possible on the high gear by proper use of the throttle and spark, and the change down to the lower gear made as soon as the motor begins to labor or is in danger of stopping. The presence of an unusual number of passengers in the car will affect its ability to negotiate grades which ordinarily are taken on the high gear, and the autoist should remember this and not attempt to force the car to travel on that gear with the increased load, but resort to a lower gear.

Changing with Selective Gearing. Of the two chief varieties of sliding gear the selective is in universal use. The most familiar form employs a sort of grid with communication between the two slots through a gate or passage cut in the bar at right angles to the slots. A lever works backward or forward in either of these slots and can be shifted from one to the other through the communicating gate. The ends of the slots represent the positions of the lever when certain gears are engaged, and in the illustration, Fig. 17, the lever is seen with the third or high gear in mesh. For changing from third to second gear the procedure is shown graphically. The first position is with the clutch engaged and the gear lever in third gear position, the clutch being shown above the grid. The second position shows the clutch disengaged and the lever being moved toward the second gear position, marked 2 on the grid. The third shows the lever in second gear position and the fourth, the final step in the change, the clutch again engaged.

The procedure is the same in the case of a progressive sliding gear.

Changing from Second to First Gear. Fig. 18 shows the change from second to first gear on the same grid, the upper line of figures showing the movement of the clutch pedal and the central line the corresponding movement of the accelerator, or throttle. The first position shows the clutch in and the throttle open ready for the change: the second shows the clutch withdrawn and the lever moved

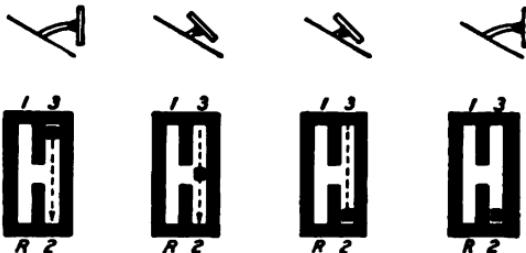


Fig. 17. Movement of Clutch Pedal (top) in Changing from Third to Second Speed (bottom).

along the slot until opposite the gate; while the third shows the lever being moved through the gate and along the other slot toward the first gear position, this sideways and forward movement being combined in one continuous movement. The motor having speeded up as soon as the clutch is released, it is necessary to reduce its speed somewhat before engaging the second gear, so the accelerator is shown partially released in this position. The gear is then engaged, the clutch let in, and the accelerator again depressed, which is the

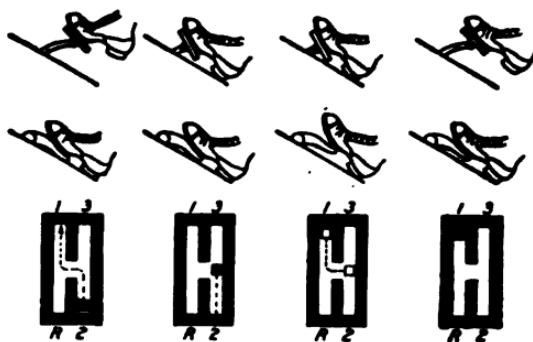


Fig. 18. Movement of Clutch Pedal (top) and Accelerator (middle) in Changing from Second to Low (bottom).

situation shown in the fourth position. A change from first to second is made in the reverse order, except that the accelerator pedal is not released unless it is necessary.

Use of the Spark.

Upon the proper use of the sparking device depends the economy of the

motor, and in many cases the safety of the driver. On some cars the sparking point on the magneto is fixed, and the autoist controls the car by the throttle only. There are a number of cars in use which employ the battery in connection with separate coils or a single spark system, or a magneto on which the spark can be regulated by the driver. When starting, the spark—in the case of battery ignition—should be retarded to prevent back-firing, and—in the case of magneto ignition—should also be retarded to a certain point, depending on the motor and magneto. When it is desired to slow the motor down below the point obtained by throttling only, the spark is likewise retarded. In ordinary running, a position of the spark lever can be found which will give fair average results through a considerable range of speed without changing its position, and this position varies with each motor and can be found by experience. When a higher rate of speed is desired, the throttle is opened and the spark advanced gradually. If a grade is to be negotiated it should be "rushed" if possible, the throttle being opened full and the spark well advanced until the motor begins to slow down

and "knock," when the spark should be retarded to correct this. The autoist should always keep the spark as far advanced as possible, without causing the motor to knock. When accelerating or retarding, the spark should follow the throttle, the latter always being operated first.

Driving at a Constant Speed. One of the best lessons on the proper method of driving a car is that of driving at a constant speed, no matter what the road conditions. The autoist should previously determine a speed compatible with the nature of all roads over which the car is to pass, and should see that the speedometer hand keeps at the determined speed throughout, regulating the spark and throttle and changing gears if necessary. Considerably more will be learned about the flexibility and power of the motor by driving in this way for a few times than by driving many times in the ordinary way.

Reversing is Usually Neglected. Among other things connected with driving which is apt to be neglected is reversing or driving a car backward. Usually a car is never reversed for more than a few yards at a time and the maneuvering involved requires no great skill. Steering a car when running backward is diametrically opposite to that when running forward. A turn of the wheel to the left steers the car in the opposite direction, to the right, and *vice versa*. The usual mistake made in reversing is in turning the steering wheel too far and describing zigzags in the road as a result. The autoist should remember that *the reverse gear of a sliding change gear should never be engaged until the car has been brought to a full stop.*

Practice Zigzagging. In addition, the novice should practice zigzagging back and forth, with a slight movement to one side each time. This is such a motion as would be needed to place a car in a small space in public garages, where every foot is of value and use, consequently the location of each car must be very exact. This is obtained only by reversing for a short distance, noting that the car must be moved say a foot more to the right, then coming forward with the wheel turned slightly to the right, then reversing again. Possibly the driver will then find that he must still go a short distance to the right, or perhaps he has gone too far and must come back. In either case, this means coming forward with a slight turn to the steering wheel, then backing straight in to preserve the gain made on the forward movement.

Systems of Control. Shifting a gear lever and pressing a clutch pedal does not constitute all that has to be learned about the control of a car by any means; in fact, to be frank, it is just a beginning. Each single action is of itself simple, as the sliding of gears, and the action of throwing out a clutch. So, too, is the throwing on of the brakes and the movement of the spark and throttle levers, but the really hard part is when it becomes necessary to do all of them simultaneously, that is—throw out the clutch, drop into low speed, throw on the brakes, shut down the throttle, and retard the spark: six complete and decidedly different actions at once, if both brakes be used.

As exemplifying the ordinary cases, several typical control

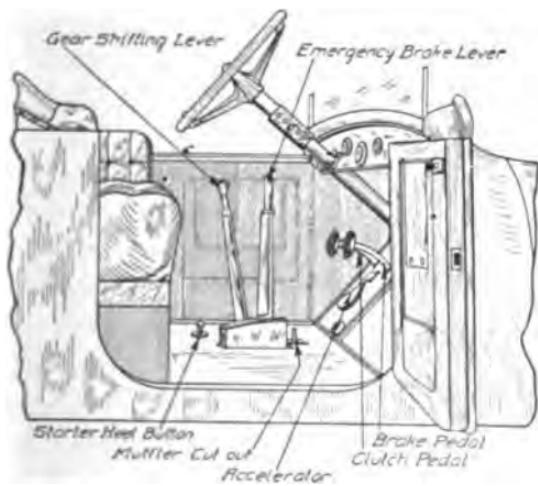


Fig. 19. Drawing Showing Complete Overland Control Group

systems will be shown and explained. The first, illustrated in Fig. 19, is that of the Overland car, previously shown in Fig. 3. This has no less than eleven components to the control system. First, there is the steering wheel, which governs the direction of the machine; second, is the speed lever, which controls the speed at which the machine can

travel; third, is the emergency lever outside of the speed lever, and the most prominent in the illustration; fourth, is the clutch pedal, the one on the left; fifth, is the service brake foot pedal, which is placed at the right side of the footboard; sixth, is the foot accelerator, located on the footboards at the right toe; seventh, the muffler cut-out, an effective signal to teams and others; eighth, the toe switch for cutting off the ignition in an emergency, often omitted; ninth and tenth, the spark and throttle levers placed on the steering wheel; and eleventh, the starting button or lever. In addition, the horn might be put down as the twelfth item, while there is the speedometer to watch in order to keep within the legal speed limit, the oil pressure gage, the gasoline gage, and at night,

the various units in the electric system, notably the ammeter. Practically all modern cars have an electric horn. So the poor novice is bewildered with no less than thirteen or fourteen things to control at once, to say nothing of the motor itself, or its ignition, water supply, and numberless other parts which might not work—in which case, the motor might stop or, if it continued to run, might be ruined. Thinking all of these things over it is apparent that there will always be some people who will not and cannot learn to drive.

Early Tendency Toward Simplicity of Control. A few years ago simplicity of control and the appearance of the dashboard were very essential features, and of considerable value in selling. There were but two pedals and two levers, besides the usual throttle lever. The spark lever was omitted, owing to a special design of magneto. This tendency reached its height just before starters were perfected, and just previous to the general change to left-side control. Moreover, this was just before fore doors became general, these enclosing the driver's compartment so that there was less need for the clean dash.

Development of Instrument Board. With the enclosing of the driver's compartment by the use of fore doors, came also the use of a deeper dash in order to get a smooth and pleasing curve to the exterior line where the hood finished off into the dash with its windshield attachment. With this depth of dash, or as it has been renamed, cowl, it became necessary to locate the various indicators and gages elsewhere than on the dash. This problem was solved by the construction of what is now known as an instrument board, a wide flat member set at right angles to the exterior line of the cowl, but placed on the inside. In this position, it is nearest to the driver. Moreover, the slight slope which was brought about by placing it at right angles to the cowl made it easier for the driver to see anything on it. At about the same time that this use of an instrument board became general, starting systems came into use as well as electric lighting. These two improvements added a number of buttons, switches, and gages to the control, which had not been previously necessary, and obviously, these were placed on the instrument board. This is said advisedly, although a few makers have concentrated their control group elsewhere, as on the steering post, in a special box placed alongside the steering post, and elsewhere.

To illustrate this more clearly, the instrument board of the Overland car is shown in Fig. 20, although this particular car has a small group of five buttons for the horn, magneto, headlights, sidelights, dash, and tail lamps set in a small box on the side of the steering post, with a key for locking them. Even at that, the instrument board carries the speedometer, the oil sight feed, the carbureter adjustment, and the ammeter for the electric system. On a car which did not have the electric buttons separated, these would be found on the instrument board with those just described.

On the Packard, the electrical control and the ignition lock are grouped on a control post, in front of and supported from the steering post, with a hollow tube down to the frame through which the electric wires run.

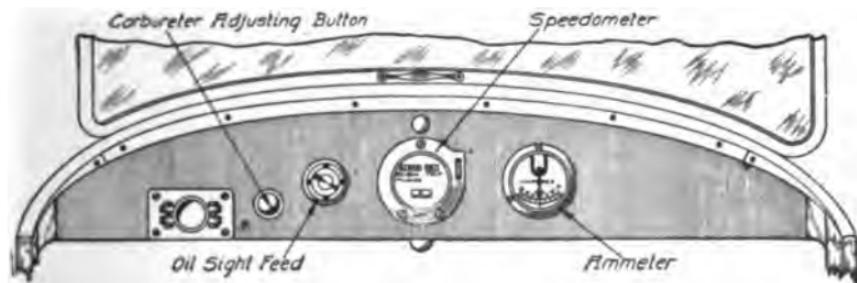


Fig. 20. Instrument Board on Overland Cars

The more usual plan—and the more reasonable one, since all the units cannot be placed on a control or steering post, and separating part only adds complication—is to place all on the dash. This is shown very nicely in Fig. 10, which at the same time presents a most complete equipment. This shows all the units included on the Overland post and dash grouped neatly on the dash, with these changes. There is no carbureter adjustment but a priming button replaces it; a voltmeter replaces the ammeter; an oil pressure gage replaces the oil sight feed.

The precise location of this board may be seen by referring to Figs. 3 and 19, in which the forward part of the same car is shown. An idea of the instrument board on other cars may be gained by referring to Figs. 10 and 21. The former shows how the units are grouped at the left side of the car (it has left-side control) close to the driver's hand. In this, one additional member will be noted that has not been mentioned previously—the hand pump for the

gasoline pressure tank. This tank is located at the rear end of the chassis and, if the pressure falls while the car is standing, it becomes necessary to have a hand pump with which the pressure can be brought up to the point where fuel will be forced to the carburetor, in order that the car can be started, after which the engine acts as the source of pressure.

In Fig. 21, showing the Hudson Super-Six control, it will be noted that the dash is extremely simple, practically all of the units being grouped in one small unit in the center (this car has left control also) of the instrument board. Upon the dash are mounted a magnetic speedometer, ammeter, pressure gage, lighting switch with special lock control, gasoline and air adjustment to the carburetor, an adjustment for hot or cold air, and a strangler. Here also there is an auxiliary hand pump for the gasoline tank.



Fig. 21. Control Group and Instrument Board of Hudson Six-54

Hudson Motor Car Company, Detroit, Michigan

The latter is located in the frame at the rear, the gasoline being supplied from this main tank by a vacuum system to a small supply

tank mounted under the hood. From this latter tank the gasoline is supplied by gravity to the carburetor. The hand pump is designed to be used only when the vacuum system fails to work.

Development of Left Control. With the general shift to left-side control, which came with a full realization of its advantages, and only after the public had realized that this was a better and more logical position, came also the central placing of the levers. The advantage of the latter was twofold; *first*, it retained the use of the right hand; and *second*, it simplified the construction, eliminating thereby many parts and some weight.

As the majority of people are right-handed, they place more confidence in that hand; in automobile operation, the majority of cars produced have had right-hand levers, and people have become accustomed to having them and seeing them there. As Fig. 22 will show, the central placing of the levers has resulted in bringing transmissions up closer to the engine, to a position in which the levers

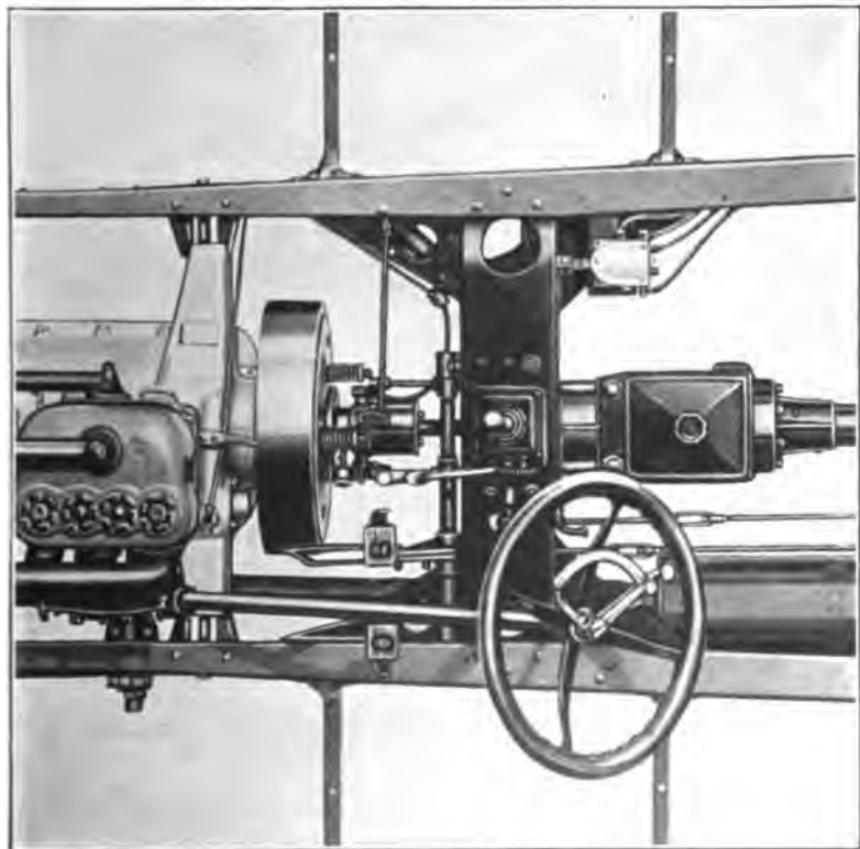


Fig. 22. Center of Mitchell Chassis, Showing Simplicity Resulting from Left Control, Center Levers

could be placed directly upon the top of the gearbox. This saved rods, levers, and shafts, with their supports and connections.

Examples of the effectiveness of left-hand drive are shown in Figs. 23 and 24. Of course, as is the universal practice, the clutch pedal must be depressed by the left foot at the moment a shift of the gears is made with the right hand as shown in Fig. 23. In case

of an emergency stop, the left foot throws out the clutch and the right foot depresses the service-brake pedal. At the same instant the right hand operates the emergency lever in the center of the car as



Fig. 23. Correct Position for Shifting Gears



Fig. 24. Proper Position for Applying Emergency Brakes

shown. When the danger is over the gear-shifting lever must be shifted to "low" before throwing in the clutch.

In Fig. 25 is shown a novel but convenient arrangement of the control levers, this being the Locomobile design. The two levers

are not placed together as is usual, but are divided, one the gear-shifting lever being placed in the center, while the other the emergency brake lever is placed on the left or outside. Both are set back close to the seat. Notches in the cushions allow of their movement.

The levers are small in size and short in length and these virtues combined with their location close against the seat, take them out of the way and thus free the front aisle for entrance from either side. The makers of this car claim that the surface of the foot brake is so great that there is seldom need, not once in a month, for using the emergency. The left hand can become as skilled in the simple operation of pulling this backward in a few days' practice as is the right. The more important movements of the gear lever are performed perfectly by the skilled right hand.

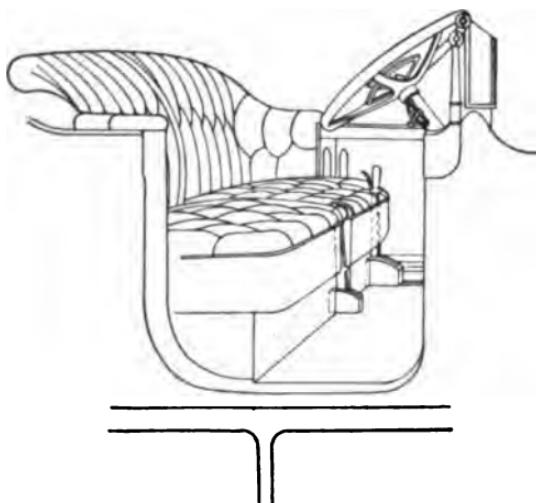


Fig. 25. Control Group of the Locomobile Showing Use of Divided Levers

STEERING GEAR

Mention has been made several times of the steering gear, and this plays a very important part in the operation of a car. Fig. 26 is a good illustration of the Peerless steering gear, and although it does not reveal the internal construction of the gear, it shows the operating lever at the base, the motion of which results in the movement of the wheels. The spark and throttle levers which connect directly to the magneto and carbureter, respectively, are seen, one below the gear, and the other near the top of the casting which holds the gear to the dashboard.

CLUTCH

One of the most puzzling sources of trouble is the clutch. The reason for this lies in the fact that it is seldom described to the novice,

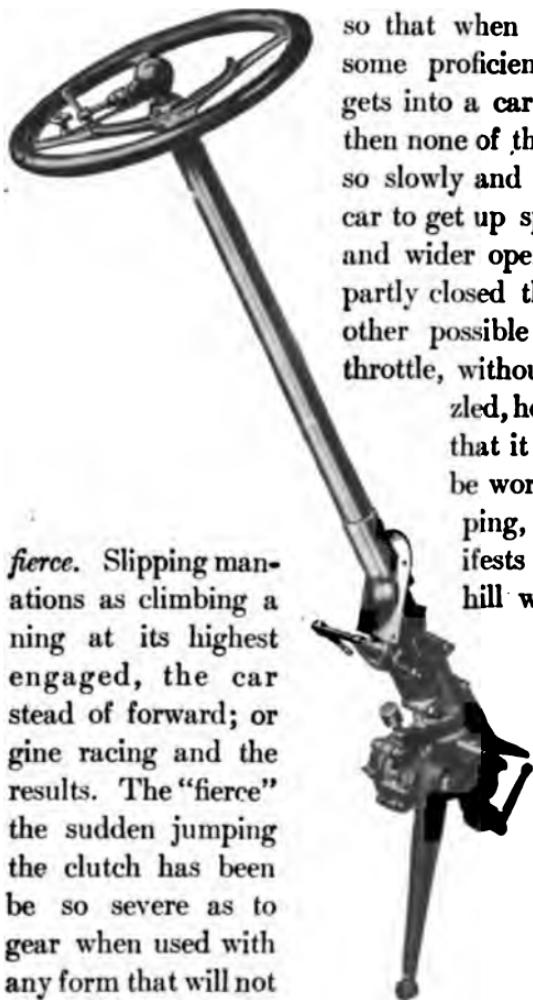


Fig. 26. Steering Gear of the Peerless Car.

fierce. Slipping man-
ations as climbing a
ning at its highest
engaged, the car
stead of forward; or
gine racing and the
results. The "fierce"
the sudden jumping
the clutch has been
be so severe as to
gear when used with
any form that will not

To repair the
surface of the leather
lubricating oil on it.

If so, wash the surface well with gasoline,
and roughen a little with a coarse file.

The harsh or fierce clutch is remedied by the application of a proper oil. Neatsfoot or castor oil is universally used, and a good way is to soak the complete clutch in it over night. This will cure a case of harsh leather, but it may be that the trouble is only a lack of adjustment of spring tension. Usually there is an adjusting nut and a locking nut. Back off the latter and make an adjustment, then tighten the lock nut to retain it. For the beginner, it is better to adjust a little at a time and make several success-

so that when he thinks he has assumed some proficiency in driving, some day he gets into a car with a slipping clutch, and then none of the little things he has learned so slowly and painstakingly will cause the car to get up speed. He tries more spark and wider opened throttle, less spark and partly closed throttle, and all of the "57" other possible "varieties" of spark and throttle, without any result. Sorely puzzled, he appeals for aid, and is told that it is the clutch. This may be working properly, it may be slipping, or it may be what is called *ifests itself in such pleasant situations as climbing a hill when, with the engine run-*

speed and the proper gear starts to run backward instead of forward, with the engine in high gear in, no speed condition shows itself in forward of the car when let in, and it may even shear off the bevel driving studded non-skid tires or slip easily.

slipping clutch, see if the is in good shape but has

sive jobs of it than to try to do it all at once. But always adjust it as soon as possible.

CHAINS

While there are not as many chain-driven cars as there were formerly, still there are now and always will be a number of the highest powered cars driven by the double-chain method. This is an efficient drive, mechanically considered, but has fallen into disfavor, because of its noise and dirt. Both of these, however, can be reduced to a minimum.

The owner or driver of a chain-driven car should learn very early in his driving career to care for the driving chains in a proper manner. While chains have been known to run an entire season without any care or additional lubrication, this practice is to be deprecated. To care for a chain properly, one should get into the habit of lubricating it at such intervals that they occur before the chain is in need of the oil. In addition to this regular lubrication there should be some set time at the end of which the automobilist takes the chain off, cleans it thoroughly, and inspects it in order to detect faults. A month is a good length of time for this. An excellent way to proceed is to take the chain off and let it soak in a pan of kerosene over night. By morning, all of the dirt will have passed from the chain to the liquid and can be found at the bottom of the pan. Clean the pan and put the chain in it and wash off with gasoline all traces of the kerosene. Having done this, hang the chain up to let the gasoline evaporate.

The chain then will be both clean and dry. Now inspect all rollers, links, rivets, and bushings, taking note of any unusual wear as indicated by looseness or play. If defects are found, they should be remedied. Then, having the chain clean, dry, inspected, and passed upon as O. K., an excellent method is to soak it, or, better, boil it in a heavy melted lubricant. The best quality of beef tallow mixed with a little graphite is good. Many do not like the latter, in which case a high-grade oil may be substituted.

LIGHTING SYSTEMS

Any part of the car liable to be put to use should have intelligent care. Thus, the lighting system is used only at night, but should

be kept in first class order at all times, so that when night falls, the whole system will be ready to go to work at once.

ACETYLENE SYSTEM

Care of the Generator. The interior of the carbide chamber or basket is more or less in contact with the water distribution apparatus and the parts of both apparatus are liable to clogging by the formation of lime residue in the generation of gas. If this residue is allowed to collect, it will have to be removed with a chisel, which is a ticklish operation in a light construction like that of a generator, especially around the water valve or its outlet. Acids are sometimes used to remove the deposit, but as they eat the metal, their use should be prohibited. The basket and pot should be thoroughly washed out frequently with water, the water outlets being cleaned with special brushes, when these are obtainable, or by wires, to remove all traces of lime. The water valve should be scraped and tested to see whether it seats properly, care being taken not to damage the valve or its seat in so doing. While the valve is dismounted for cleaning it would be well to see that its stem is straight and that it works with some ease in the threaded portion attached to the water chamber. Both generator and lamp gas valves should be cleaned and should seat snugly, so that there will be no leakage past them.

The best position for the generator is on the running board just back of the change-gear quadrant, and sufficiently far out from the frame to allow a free circulation of air all around it. The generator will keep cool in this position and will perform its work to the best advantage when properly cooled.

The Much-Neglected Condenser. When used at all, the condenser or its substitute is put off in some position where it becomes caked with mud and is almost forgotten until it is full and the lamps begin to flicker. Then the mud is cleaned from it and it is drained out. It should be placed so that it is close to the lamps, where it will catch all of the condensation from the gas going to the burners, and in addition any water that may enter the burners due to washing of the car. It should be emptied from time to time, say once or even twice a month, when the lamps are in regular use. The majority of troubles with acetylene lamps are due to lack of a condenser and to the use of too small metal tubing.

Regarding Tubing and Gas Bags. Copper tubing is considerably used for piping the gas to the burners, but it is liable to erosion by the gas, and standard $\frac{1}{2}$ -inch iron gas pipe is better and lasts longer. The gas-bag and rubber lamp connections should be kept clean and not painted, as is often done to correspond with the car, as paint rots the rubber, with the result that it is soon unserviceable and must be replaced. When the rubber is to be washed, only water should be used and the goods should be carefully dried before putting them in service again.

Care of Rubber Tubing. On gas-lamp systems, the lamps are connected usually by means of short pieces of rubber tubing. Aside from the fact that their position at the front of the car brings them hard usage, mud, dirt, water, etc., the rubber is usually so short that a bending stress is imposed upon it all of the time. At any rate, this tubing depreciates very rapidly and needs replacement every season and generally twice a season. Instead of rubber tubing, a good plan is to get the covered flexible metal hose with rubber ends. This does the same work and is practically indestructible, the metal hose lasting a lifetime.

Location of Gas Tank. The gas tank should have considerable thought also. If the car is used very much at night, so that a tank full of gas does not last very long, the position of the tank and its easy removal and replacement are of prime importance. On the other hand, no matter how much the car is driven, it is important to have the tank so located that the driver can see the gage on it readily. Generally the tank is carried on the upper or under side of one of the running boards. This makes a first-class position, except when much country driving is done, in which case the bottom side location is a poor one, subjecting the tank to much water, mud, and other road dirt, as well as actual contact with the road in places.

In many cars, the copper tubing which leads to the lamps is placed up close to the frame, sometimes inside the channel section. This is an excellent plan for it protects the copper tubing which is easily broken or bent enough to shut off the flow of gas. Where such is not the case, the motorist would do well to see if it can not be moved to that place, or otherwise protected so that it will be impossible to dent, bend, or break it.

and lining the lamps up in a proper manner, Fig. 27. This does not need to be done often, for the lamps do not work out of position, so if well done at first, they will always appear well. Since the lamps have considerable breadth, and may be assumed to be made square, by placing one and fastening it, the straightedge will indicate the proper position of the other. With that placed, the straightedge may be called upon again, to decide if they line up correctly. If they do, tightening the bolts locates the lamps so that they not only look right but are right.

ELECTRIC LIGHTING SYSTEM

Care of Storage Battery. Evidently, in an electric lighting system, the storage battery is one of the most important units in the system and should be kept in good condition. This is filled with a liquid called the electrolyte or acid solution. When the battery is in constant use, the electrolyte deteriorates and loses its strength, which is shown by its reduced specific gravity. Consequently, it becomes necessary for every owner to have a specific gravity hydrometer with which to measure this. In general, the reading on the arbitrary scale of this instrument should be above 1.275, while 1.280 is recommended. When the owner tries the battery and it does not come up to this figure, he should run the engine long enough to raise the gravity to this point. If the battery is looked after every two weeks, it will be found that running the engine for an hour or less will do the trick, but if not cared for oftener than once a month, it will have to be run much longer than that. In addition, the owner is taking a chance of spoiling the battery by letting this simple inspection go.

In case the battery gets low when the car is not in use as, for instance, when the car is stored for the winter, the best plan is to empty it. This should be done as follows: Charge the battery fully, either by running the engine, by means of a separate charging rheostat or mercury rectifier, or by taking the battery out and taking it to some garage which has charging facilities. In this case, it should be charged until it "gasses" freely, that is until a considerable quantity of gas bubbles up through the liquid and is given off. Then empty each cell of electrolyte, remembering that this is an acid and will attack ordinary pipes or drains. When all the liquid has been cleaned out, the cells should be washed or rinsed with distilled

water or, if this is not available, with clean rain water. This should be done thoroughly, rinsing at least twice and preferably three or more times. Then replace the plates and seal the case with paraffine or wax, sealing as well all vent plugs, the small holes in the center and all around the edges, so that no air can get in. This is done to retain the moisture on the plates, as that keeps them in good condition; otherwise they would dry out and lose their active properties. When it is desired to use the battery again, new electrolyte must be put in.

The reason why the battery should be fully charged before emptying off the liquid is that a large part of the active material making up the battery plates is likely to be in solution. Thus, it would be thrown away with the electrolyte and wasted. The plates could then never be restored to their former good condition, and after very little more use, new ones would be necessary. Consequently, while charging the battery before taking it down to put out of use for a fairly long period may look foolish, it really is a wise and economical thing to do.

In addition, the following points are of importance in the location, fastening, and care of the battery. Such of these as the manufacturer of the car has not attended to, the owner of the car should look after. Above all the battery must be accessible—for repairs or replacements when such become necessary; for testing, as pointed out previously; and for the addition of water to the electrolyte. The compartment in which the battery is kept should be well ventilated and drained, should be protected so as to keep out water, oil, or dirt, and must be so located and constructed that there is no opportunity to lay things on top of the battery. The battery should have free air spaces on all sides, should rest on cleats rather than on solid boards, and should have holding devices which grip the case or the handles, never the cell itself or the terminals or top part. The cover, too, should be so constructed as not to press down upon or touch the cell tops or terminals.

Care of Generator or Motor. The generator, or motor, or combination unit, is constructed usually so as to require little or no attention. At each end of the armature there is a bearing, and usually just above this is located an oil cup or, in some cases, a grease cup. These should be kept filled, as in the ordinary case of a grease or oil cup. One maker recommends three or four drops of

oil every 1000 miles, another suggests a drop of oil every week, and a third a turn of the grease cup every two weeks.

The commutator should never be oiled; on the contrary if oil, grease, or other lubricant gets on it, trouble will result, necessitating wiping it clean. As the copper surface of this part wears from the constant contact (rubbing) of the collecting brushes upon it, it is liable to wear unevenly. When this happens, or when the surface becomes blackened or rough from any cause, it should be trued up by pressing on it, while running, a piece of fine sandpaper. This should be done very carefully, using sandpaper only—never use emery paper or loose emery—and that, too, only of the finest size. When the surface has been cleaned or smoothed up to an even bright surface, all particles of dust, sand, or metal should be removed from its surface, using particular care not to leave any metal filings or dust between the copper segments. If these cannot be removed otherwise, blow them out with the breath or an air hose. In addition, the carbon dust which has worn off the brushes should be blown out of the bottom of the case.

Driving Members. When the generator is driven or the motor drives through any form of chain, this should have occasional attention. All chains stretch more or less, although silent chains, which are used for this purpose usually do not stretch as much as roller or block chains. Moreover, looseness in a silent chain is not a fault, as they are used loose. Slackness on a block or roller chain, however, is a fault and must be remedied by tightening. All chains require lubrication, using ordinary lubricating oil. This should be used frequently, the exact frequency depending upon the amount the car is used. It is recommended that the chain length be adjusted just after the first 1000 miles has been concluded, and then not again until 10,000 miles have been traversed.

Carbon Brushes. The brushes which press down upon the copper commutator, and thus collect the current, are of considerable importance. All makers unite in recommending the use of the very best carbon obtainable, regardless of cost. A poor brush with hard or soft spots in it will cause endless trouble. The whole end of the brush must be in contact with the commutator, not just one small edge. Brushes should be free in their holders, that is, they should not stick. If they do, they should be removed and cleaned of any

dirt, grease, or foreign matter which causes this sticking. At least one of the brushes is entirely insulated from the generator case and is connected to the field winding. This is done for regulation purposes, and the owner should never change or disturb this brush.

Care of Wires. It is highly important that all wires be kept whole, covered with insulation, well joined, soldered and taped at all connecting points, and as free as possible from liquids. The latter, as water, oil, etc., soak through the insulation and when this reaches the inner wire, a short-circuit path is formed because liquids will conduct electric current. In general, it is not sufficient to twist the ends of wire together; they should be joined as carefully as possible, then soldered together so as to make a perfect connection, then the whole thoroughly covered with insulating tape, wound on as carefully as time will permit.

The connector plugs at the lamps sometimes show a current leak. These should make close contact (both halves) and the main connection should be well soldered and protected. If the wires within the lamp are not tightly connected or carefully insulated, no light will result and, in addition, a short circuit may result. Practically everything which has been said about care of wiring under ignition applies with equal force to lighting wires.

ROAD REGULATIONS AND PRECAUTIONS

Early in his driving career the novice should cultivate a sense of fairness toward other drivers of automobiles, toward vehicles other than automobiles, and toward pedestrians. There is too little of this, and it may be said without fear of contradiction that this absence has done much in the past to retard the development of the automobile in rural districts; in fact, it has brought out a feeling of antipathy there which is but now being dissipated.

Passing Horses on the Road. The majority of horses encountered on roads frequented by automobiles to any extent pay comparatively little attention to them, even when passed at fairly high speed, and of the remainder it is safe to say that most are not nearly so alarmed as their drivers, who communicate the alarm to the horses through sawing on the bit, shouting, or dropping the reins. The exceptions are young horses or those which have not been given sufficient road driving. In passing horses, the autoist should not only

observe the actions of the horse, but also those of the driver. If the horse exhibits signs of being restive, the voice has a very quieting effect. Expressions such as "Whoa, boy," said in a reassuring tone will, in many cases, be sufficient to soothe the animal until the car can pass.

The best manner in which to pass a standing horse headed in the same direction as the car is to cross to the far side of the road and drive by quietly at the legal speed. The horse will be only slightly startled, if at all, and will not bolt or back, as the alarming object and its terrors are gone. More care is necessary in passing a horse headed in the opposite direction, as the animal can see the car coming and has time to become fidgety. If the driver has the animal under control, the car can be driven past at the regular pace unless signs of fright are seen, when the car should be slowed down, or stopped if necessary. The car should pass on the opposite side of the road and as soon as it is by, speed can be increased in order to get out of hearing as soon as possible.

Procedure in Leading a Horse. It may be necessary in some cases to stop both car and motor and lead the horse past the car. A number of accidents have occurred in so doing by the horse freeing his head from the bridle through improper leading. Both reins should be taken in the right hand, Fig. 28, about 6 inches from the bit and the horse patted and reassured by the voice. The autoist should then *face forward* and start off, walking alongside the horse's head until past the car. Should the animal rear, the grip on both reins prevents him from tearing free from the bridle and bolting. The usual mistakes made in leading are in grasping one rein only—which hurts the horse's mouth and may break the bridle—and walking backward while leading the horse along. As a horse will not willingly walk over a man



Fig. 28. Correct Method of Leading a Horse

and as this is the position usually assumed by drivers when hitting the animal over the head, the operation instead of having a soothing effect, alarms and confuses him. Another situation requiring care is shown in Fig. 29.

Passing cattle or other animals than horses (which have considerable intelligence) is a difficult job. Usually it requires considerable patience, much tact, and lots of time. The best plan when meeting a herd of cattle or other animals on a country road is to drop down into a low gear at once, so that the car will just crawl along. When moving at a very slow speed, animals do not seem to be frightened at the car as much as when it travels rapidly. In addition, it allows the driver to stop more quickly if a cow should take a stand directly in front of the machine, as is often the case.

Caution Needed in Overtaking Vehicles. There are two general principles to be remembered in overtaking or passing vehicles on the road. These are: Be sure there is a clear way ahead before the overtaking or passing is attempted, and never cut things so fine that a swerve on the part of the other man will cause a mishap. Quite a large proportion of road collisions come from either of the parties concerned taking chances that the other will do the right thing, which seldom happens. In overtaking another vehicle, care should be taken to ascertain that the driver is aware of your presence, particularly if he is driving a covered vehicle or one that is noisy. It is often difficult to make the other man hear, and the chances of his swinging out are too great to warrant any risk being taken. A tendency on the part of the driver to turn off to the side of the road, apparently to let the autoist go by, may be the result of an involuntary pull on the reins or may have been done to avoid a bad place in the road, and this turning off is often followed by an equal swing in the opposite direction. In following a vehicle the autoist should not keep in the other vehicle's tracks, but should stand off diagonally so that he or one of the passengers in the car can see the road ahead and



Fig. 29. Passing Cattle on a Country Road

observe the actions of other vehicles. Sufficient distance should be kept so that the autoist can turn in behind the leading vehicle in case of the sudden appearance of others coming in the opposite direction.

New Narrow Roadways. The newest method of building roads with a narrow strip of hard road—concrete, brick, or asphalt—down the center has made considerable difference in the method of country driving. For one thing, this narrow strip of say 16 or 18 feet width down the middle of a 70-, 80-, or 100-foot roadway necessitates more care. The better road surface permits of more

speed, of which nearly everyone takes advantage, this in itself constituting an additional source of danger. As is pointed out in Fig. 30, which shows one of these modern roads, only the center strip is hard, while the sides are usually left of soft dirt. From the fact that no one uses the side, it remains soft, too, so that a sudden turn off from the road surface either by accident or through necessity will



Fig. 30. New Narrow-Type of Roadway Requires More Careful Driving

bring the car up somewhat short. The narrowness of the center part emphasizes the need for each driver to keep to his right side, hugging the outer edge as closely as is possible, so that other cars approaching will have plenty of clearance at the center of the road.

Passing Moving and Stationary Vehicles. The chief point to be remembered in passing moving vehicles is always to allow plenty of room for both. The passing of another vehicle so closely that there is hardly room for a sheet of paper between them, may be looked upon as brilliant driving, but sooner or later someone will miscalculate and an accident will occur. All passing should be done according to the rule of the road prevailing in the section of the country in which the car is being driven, as the great majority of road users follow this

rule, and in case of accident the vehicle which held to the proper side of the road is generally exonerated in the courts. In passing stationary vehicles or those about to start, a strict lookout ahead should be kept for pedestrians or vehicles suddenly emerging from the rear, or in the case of a trolley car, for alighting passengers and those rushing to board the car. It is not sufficient to blow the horn and count on its being heard by those behind the other vehicle. The chances are that the sound has not been heard, and nothing but slow speed can be indulged in with safety. The same need of slow speed and extreme caution occurs in overtaking stationary vehicles as in passing them.

Passing on the Wrong Side. As a rule, all vehicles should be passed on the proper side according to the rules of the road, but there are occasions when it is unsafe to pass in this manner and the autoist has either to pass on the wrong side or to wait until conditions are such as will allow him to pass according to rule. Such an occasion often presents itself in overtaking a heavily loaded vehicle or one which has been disabled and has not been withdrawn to the side of the road. Once a loaded van or truck leaves the crown of the road, it has some difficulty in getting back again, especially if drawn by horses, and the driver will generally refuse to turn aside except for other equally heavy vehicles. As the autoist is conducting a vehicle of superior speed and mobility to that of the truck, the latter can be considered as a stationary object for the time being and passed on the wrong side, provided the road is clear. The situation is shown in the sketch, Fig. 31, where *B* is a truck and *A* is a car about to pass the truck. The road being clear, car *A* can take the course *a*, passing the truck on the wrong side. Should course *b* be taken, a collision is likely to occur between the car and another car *C* proceeding in the opposite direction, unless great caution is exercised by both drivers. If there is any doubt as to the road not being clear, the autoist should take no chances but wait until the way on the left of the truck, course *b*, is clear and then pass on the proper side. Situations like the above occur from time to time on the road and the autoist should use his judgment in coping with them. Legally it is not justifiable to depart from the rules of the road except to avoid accidents, and this should be borne in mind at all times.

Proper Negotiation of Road Crossings. In approaching road crossings the autoist should slow down to a speed at which he can pull up on the brake within the length of his car, and blow his horn for the purpose of warning other road users of his presence. As the car approaches the crossing, a sharp lookout should be kept for traffic on the intersecting road, and as soon as the way is seen to be clear the crossing should be taken as quickly as possible. Particular care should be exercised at crossings where one road is partially or totally hidden from the other until the

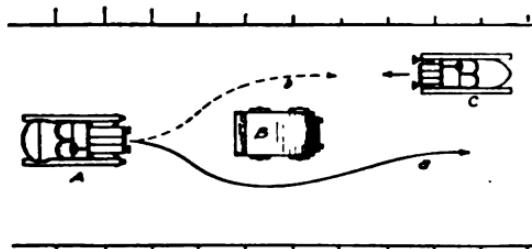


Fig. 31. Case Where Passing on the Wrong Side is Excusable.

crossing is reached, especially in the smaller towns, as light carts, bicycles, or, in fact, vehicles of any kind frequently emerge from the side road at speed and in the most careless manner, even when those in control are unable to see anything that is approaching on the main road. In anticipation of such performances the car should be kept to the center of the road so as to be able to turn aside to avoid a collision, for if the horn has been blown, there is no way of knowing that the driver of the other vehicle has heard it. Even if vehicles on the intersecting road can be seen, great caution must be exercised, as there is no indication that they are going to continue along the side road nor in which direction they will turn into the main road. Passing partially hidden road crossings at speed is absolutely dangerous because of the long chances which reckless autoists take at such places.

On Approaching a Blind Turn. Frequently encountered in suburban towns is the blind turn, where a cross street or road terminates in one of the main roads and the view from either road is obscured by buildings or fences until the turn is reached. At such turns the chances of accident are greater than at road crossings, as at these latter places an autoist has three directions in which he can turn to escape collision, while at blind turns there are but two, with the chances in favor of the car on the side road. Referring to the sketch, Fig. 32, A is a car about to enter the main road and proceed thereon in the

right-hand direction, and *B* and *C* are cars coming along the main road. Owing to the high fence on one side and the building on the other, *A* cannot be seen from *B* or *C* until the lines *ax* and *bx* are reached, neither can *B* nor *C* be seen from *A*. The sound of a horn from either road likewise cannot be heard from the other. Under the circumstances, car *B* should keep to the center of the road as in negotiating road crossings, and car *C* should keep to the right-hand side of the road and proceed cautiously. When the car *A* makes the turn into the main road, it should take the path shown by the dotted line, swinging well out to avoid a possible collision. Car *B* has thus an opportunity to turn aside and avoid *A*. Should *A* turn to the left into the main road, car *C* is in no danger even if the driver

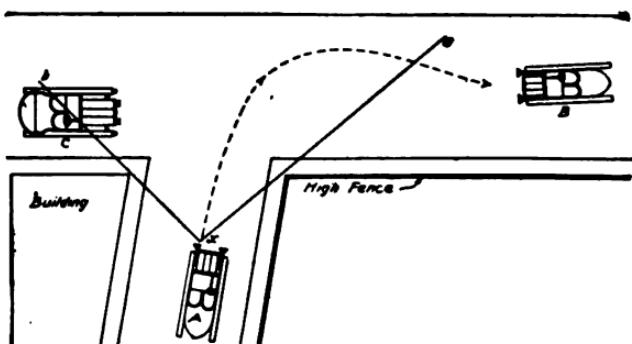


Fig. 32. How to Negotiate a Blind Turn

of the former car cuts the corner closely. The positions shown in the sketch should be assumed at all times when approaching a blind turn whether the presence of a car on the other road is known or not.

The French experts consider the above an excellent argument in favor of the left-hand location of the control, *i.e.*, the driver with all of the steering and controlling mechanism located on the left rather than on the right. The way the argument goes is like this—a man sitting on the left can see farther around a blind turn like the one just described than a man located on the right. Therefore the driver placed at the left would be able to avert a fatal collision more easily.

Operation of Left-Hand Drive. The idea that the left-side location of the driver—in opposition to the method on horsedrawn vehicles, which was adopted at first—is the better and safer method is growing very rapidly in this country, as witnessed by the large

number of makers turning toward it as the final solution. With the big producers and real leaders like Ford, General Motors, Hudson, Chalmers, Packard, Locomobile, and others turned toward it, there was no question how the balance of the industry would go. Now, in 1916, there are altogether 11 chassis left, including Pierce with 3, Fiat with 2, Stutz 2, Dispatch, Morse, and Simplex 2. The latter, however, uses left drive on the Simplex-Crane, its leader which is

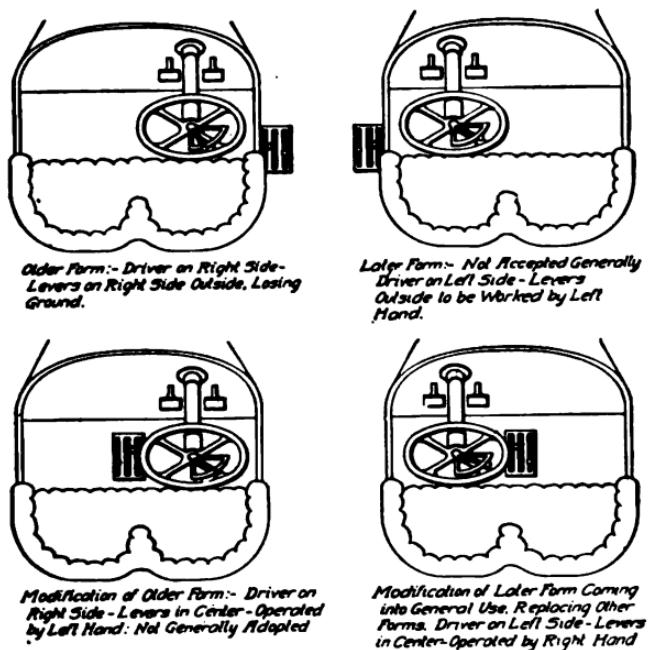


Fig. 33. Various Control Arrangements

being pushed, which may foreshadow its use on all Simplex models shortly. There would then be but five firms left.

Advantages. The advantages of left-sided location are being admitted, but as to the lever location there has been more argument. When the first changes from the right side to the left were made, many changed the levers over also, placing them on the outside as before, which brought them to a position where the left hand had to be used, which did not become popular. In Fig. 33 are shown the four locations. The first and second indicate the original position and the shift just mentioned. The third, which was tried by a number of makers, was to leave the driver on the right but shift the

levers to the center, to gain the constructional advantages and saving which go with that position. As will be seen when the advantages of the left-sided location are pointed out, this gained nothing for the driver. Like the second form it represented a makeshift, and did not become popular. The fourth form, which is now becoming popular, gives the driver all the left-side advantages as well as right-hand operation of the levers, while at the same time, it gives the manufacturer all the savings of parts, weight, etc., in fact, all the constructional advantages of the center positioning of levers.

The advantages to the driver are pointed out graphically in Fig. 34. There are six parts to this, as follows: At *A* is indicated the advantage of being on the left when overtaking and about to pass a vehicle going in the same direction, but meeting one going

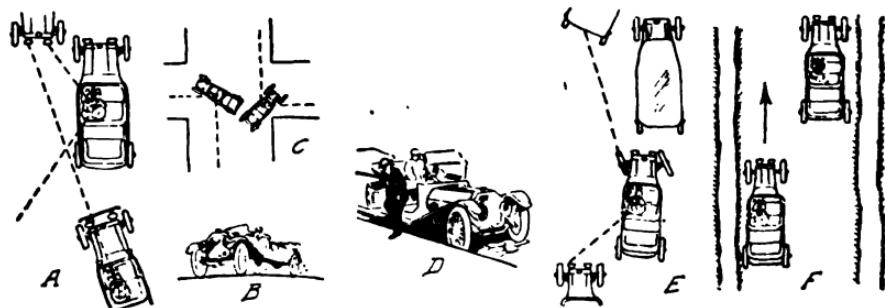


Fig. 34. Advantages of Left-Hand Control

in the opposite direction at the same time. Here the position nearer the center of the road enables him to see past the car in front and thus see the approaching vehicle much more quickly than if he had been on the right. Moreover, it enables him to see this approaching danger in time to check his own car or turn in back of the car ahead. With right-hand position, he would have to go several feet farther to the left and many more forward before this situation could be seen as clearly and then it might be too late to check the car.

In climbing a hill with the road curving to the left, the driver can see what is ahead of him more quickly from the left side, as is pointed out at *B*. At *C* is shown (by the dotted lines) how a driver can see ahead of him, back of him, and in other directions from which other cars might come, when turning a corner, either to the left or to the right. Allowing the front seat passengers to dismount at the curb, as shown in *D*, instead of in the middle of the street

was early recognized as a big left-side advantage. With a runabout, this becomes of extreme importance.

In addition to traffic ahead, it is highly important to be able to see traffic behind. As pointed out at *E*, the left position allows the driver to see what is behind him more easily than would the right location. On narrow roads and in the country, drivers generally drive faster than in the wider streets of the city and suburbs. In such a case, when overtaking another vehicle one passes to the left. The desire to give plenty of space between the two cars is minimized by the fact that a person must take the wrong side to get by. This results in a minimum of clearance between the cars and, in the case of the overtaking car, a safe clearance at the ditch. Left-side location allows the first car to look after the clearance, while the driver of the other car can look out for the ditch. This is pointed out at *F*.

City Driving. Driving in the city is very different from driving in the country and calls for a different method of conducting the car and different tactics in general. In the former, it is safest to assume that there is someone else on the street at all times, either other vehicles ahead on the street, other vehicles behind on the street, or persons on the sidewalks who may possibly come into the street ahead from other cross streets. All of these contingencies must be provided against by driving slowly and carefully, with an eye for every side, the car under complete control, the hand close to the horn so as to sound a warning signal, in short, with the driver and car ready for anything which might happen.

In the country, on the other hand, there may be no vehicles in sight either ahead or behind; there may not be a cross road for miles; there are few people around and little possibility of their cutting across the road; the speed limits are higher; in every way the possibilities for danger or trouble are very remote.

In such a situation, there is less need for instantaneous care, the car can be driven more rapidly, with less need for brakes and clutch, also horn, while the driver can have more mental ease and thus take more comfort in driving.

Not enough drivers consider the man behind. Moreover, there is a certain element of danger to one's own car, when the man back of you is not warned quickly enough of your intentions. In the eastern cities, the practice has gradually grown up of signalling

one's intentions with the arm and hand. When the driver is about to slow down, he sticks out his arm (the right for the right-side driven cars; the left for left-side cars), using the fingers and hand to indicate the extent of his stop. Thus, if the intention is to slow down only as much as the cars or other vehicles ahead make necessary, keeping the car moving all the time, this intention is indicated by moving the hand around in a circle, a sort of beckoning motion to the driver behind to keep coming. At the same time, the driver's arm is kept extended in order to indicate that slow speed and care are necessary.

Extending the arm abruptly and quickly indicates a sudden stop, bringing the car to an actual standstill. The equally sudden withdrawal of the arm indicates the removal of the necessity for this, and the ability to go ahead. When a turn is to be made, the arm is extended slowly in the direction in which the driver wishes to turn, sticking out the left arm for a turn to the left, etc. In order that the turn and full stop be not confused, many drivers extend the arm vertically or as nearly so as possible to indicate the full stop. Similarly, with a turn to the left in a right-hand controlled car, the arm is not so visible as it might be, so many drivers start the arm out almost in a vertical position, then let it drop slowly in the direction in which the turn is to be made. These and other similar and simple methods of signalling one's intentions should be used by all drivers at all times for safety's sake if for no other reason.

Be Careful Not to Get Boxed. In keeping religiously to the right when not passing a vehicle ahead—in which case the turn is to the left—the driver should be wary about being caught between a vehicle ahead and the curb stone. Fig. 35 illustrates just such a contingency. As shown, the driver waited too long before turning out to the left, and so will have to stop and back away before he will be able to pass the obstructing wagon.

The Right of Way at Turns and Crossings. Regarding the right of way at turns and crossings, the vehicle which arrives first has the priority of passage according to actual road practice. In case of a "dead heat" between two cars, it remains for both drivers to agree as to which shall proceed ahead of the other, the driver yielding the way giving a signal with the hand. Generally speaking,

horse traffic gives the precedence to automobile traffic as a matter of safety, but the autoist should not consider that he has the absolute right of way over all other road users for this reason. All users



Fig. 35. Result of Running Too Close to Other Vehicles

have equal rights on the road, but because the autoist has a vehicle of great physical superiority due to its weight and speed, he is not entitled to lord it over those not so well equipped. It does no harm to yield the road to a hored vehicle even if the action necessitates a change of gears

or a stoppage of the motor. On the contrary, courtesy does much to remove any prejudice which may exist against automobiles, particularly in rural districts, a prejudice which is fast disappearing. In general, the autoist should exercise his discretion as to what is proper under the circumstances, departing from road practice if necessary, and his individual sense of fair play should cause him to have regard for the rights of others at all times.

Granting that both vehicles are in the right, that is, on the right side of the road, proceeding properly according to law, and within the legal speed limits, the law generally considers that, all other things being equal, that vehicle has the right of way which is traveling at the higher or highest speed. Thus, in cities where traffic rules and policemen may give a fire department vehicle, patrol wagon, or ambulance the way, it is held that the speed at which these are allowed by local regulations to travel gives them automatically the right of way, entirely aside from any thought of their property- or life-saving intentions.

Negotiating Turns. The procedure on approaching a turn is exactly similar to that on approaching a road crossing. The car should keep to the center of the road and its speed should be reduced somewhat until the road is seen to be clear, when the turn can be made. In taking a right-hand turn, the autoist should keep well away from the corner, describing as large an arc as possible and gradually gain-

ing the center of the other road. Such maneuver is shown in the sketch, Fig. 36, where the car *A* follows the dotted course until the point *b* is reached. By so doing a collision with another car coming in the opposite direction will be avoided as either car can swing clear. In taking a turn to the left, a similar maneuver should be made, but in this case the car should keep close to the proper side, as in the sketch of the left turn.

The size of the arc described in making the turn will, of course, depend on the width of the road and

the length of the car, small runabouts being able to turn in an arc of 25 feet or less, while large touring cars should describe arcs of 32 feet and over on an ordinary road.

Corner Shaving to Be Avoided. Except when absolutely necessary to avoid a collision, corners should never be cut closely or "shaved" as it is often called. By shaving a corner the autoist runs chances of colliding with other vehicles, and engenders a dislike in all other users of the road not only for himself but for automobiles in general. There are numbers of drivers that habitually shave corners, who start to make the turn before reaching the proper point and cut diagonally across the road, obstructing traffic coming in the opposite direction, and hugging the left-hand corner of the intersecting road. Their desire is evidently to travel from one point to another in the shortest possible space of time, and, to save distance, cut the corners without regard to the rights or safety of others. The majority of automobile drivers of this class luckily confine their operations to city streets, although they are found in some numbers on country roads. On the other hand a large majority of horse drivers are corner shavers, women being particularly given to the practice. Because of the presence of this and the reckless classes of drivers, special caution has to be exercised at all times by those in charge of vehicles of every kind. See the turn indicated in Fig. 37.

On Approaching a Road Fork. On approaching a point where

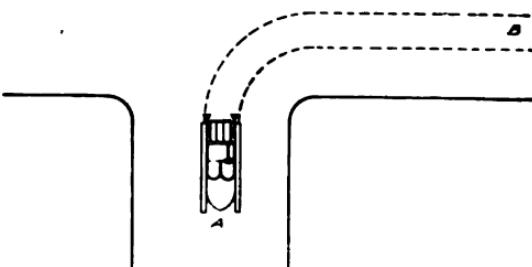


Fig. 36. Proper Turn to the Right

the road forks or branches off, the autoist should hold well over to the proper side of the road in order to avoid cars coming along the branches. Should he be traveling along one of the branches toward the fork, however, he should keep in the center, as when approaching an ordinary turn. On overtaking another car, it would be better to allow the latter to proceed on its course without attempting to pass, unless the driver signals the direction he is about to take. The reason for this can readily be seen by referring to the sketch, Fig. 38, where

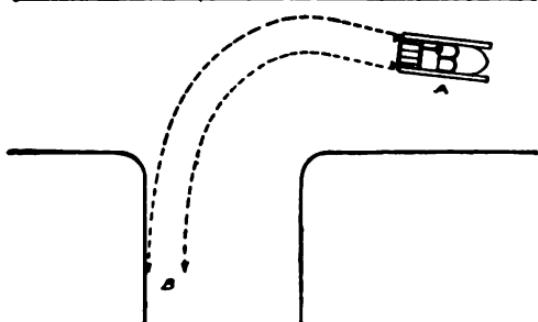


Fig. 37. Correct Turn to the Left

Hence the driver of *B* should allow *A* to take its course before proceeding on his own. If the driver of car *A* should signal the fork he is going to take, *B* can pass on the proper side if the same fork is to be taken by both, and on the wrong side if *A* is to take the left fork and *B* the right. If *A* is to take the right fork and *B* the left fork, *B* will pass in the ordinary manner.

As stated before, turns should be taken slowly, particularly, close to cities or towns. In the country, one is apt to forget this advice and whirl around the turn as if there were no turn there. An experience

with a rapidly skidding car on a turn like the one shown in Fig. 39 will cure the driver of this habit. Here an open and fast road tempts one to speed. The curves are flat, and rounding them at speed, the car would skid to a very great extent and just where the

car *B* is about to overtake car *A*. If *B* attempts to pass *A* by taking the path *y*, a collision will occur if car *A* turns down the left fork at *a*. On the other hand, if the path *x* on the wrong side is taken, a collision will occur at *b* if the leading car takes the right fork.

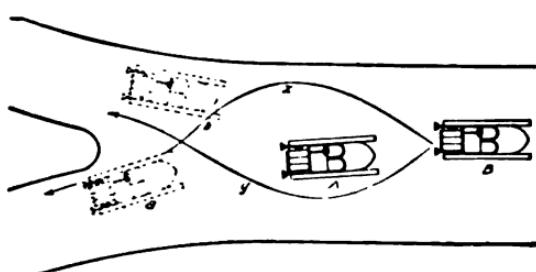


Fig. 38. How to Pass a Car at a Fork



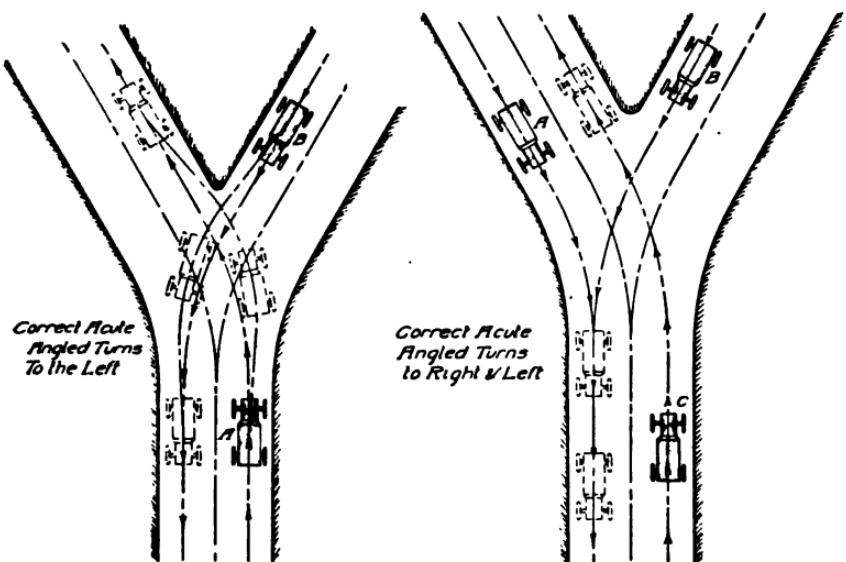
Fig. 39. Bad Turn Requiring Care and Slow Speed



Fig. 40. Road Situation Requiring Slow Speed and Plenty of Warning

skidding car will be sure to strike will be noticed a nice, soft (?) telephone pole. Another situation requiring slow speed and plenty of warning is shown in Fig. 40.

Two other phases of the forked, or Y-shaped, road are pointed out in Figs. 41 and 42. The former shows a situation in which a car *A* is going say north on the main road intending to turn into the west fork, while another car *B* is coming south on the east fork intending to turn into the main road. It is apparent that the two will meet just beyond the forking of the center lines. In such a



Figs. 41 and 42. Correct Turns to the Left and to the Right in a Y-Shaped Road Fork

situation it would be considered—at least in cities like New York where north and south traffic has the right of way over east and west and all diagonal traffic—that car *A* has the right of way since it is actually proceeding in a north direction, whereas car *B* is headed southwest.

However, the actual layout shows that car *B* would reach the point of intersection of the two paths—the point of collision, so to speak—first and thus would have the right of way. In such a situation it is well for both cars to deviate to the right slightly, thus widening the margin between them wherever they pass. The second curving line indicates this path.

In Fig. 42, the same situation is shown with a third car coming south on the west fork. From this layout, it would appear that *A* will go south on the main street first, followed by *B*, while *C* will continue north, crossing the fork only after *B* has passed.

Under Bridges Sometimes Dangerous. Fig. 43 presents a scene of more than passing interest—one in which considerable danger to the autoist may be lurking. This is a case where a road leads under a bridge and the other end of the road turns away so that it may not be seen. That is, this represents two blind turns, with a bridge added to complicate matters. The proper procedure is to approach slowly, signalling loudly, until well under the bridge, when a slightly improved view of the other road may be had. If another car is approaching, it is an easy matter to stop, and if no other car or vehicle is in sight, it is an equally easy matter to throw on full speed.



Fig. 43. A Dangerous Road Situation

Blind Courts Give an Opportunity for Skill. A driver who is skillful in maneuvering around has an excellent chance to show his skill, when caught in what is called a *blind court*. This is, as shown by Fig. 44, a court or street which has but one entrance and exit, the two corresponding. To get out it is necessary to back, come forward again, back and forward, until the car is moved around in the narrow court so as to be able to proceed in the reverse direction. In the figure, the first position is marked *1*. From this, the driver perceiving his situation, turns as sharply as possible to second position *2*. In stopping, the wheels are warped around in the opposite direction as far as possible, before moving the car—bad practice

but needed here to save every inch. Then throwing into reverse, the driver backs up to the third position 3. From there, by cutting a very close corner, he is able to proceed out of the court. Position 4 shows the final position of the car, while the dotted lines indicate its movements. A narrower court would have called for more backing than this one did.

This emphasizes in a small way the necessity for skill in zigzagging back and forth, but it does not bring out the need for practicing this in order to become skillful at it. In this case, the driver backed but once, coming out on the second forward movement.

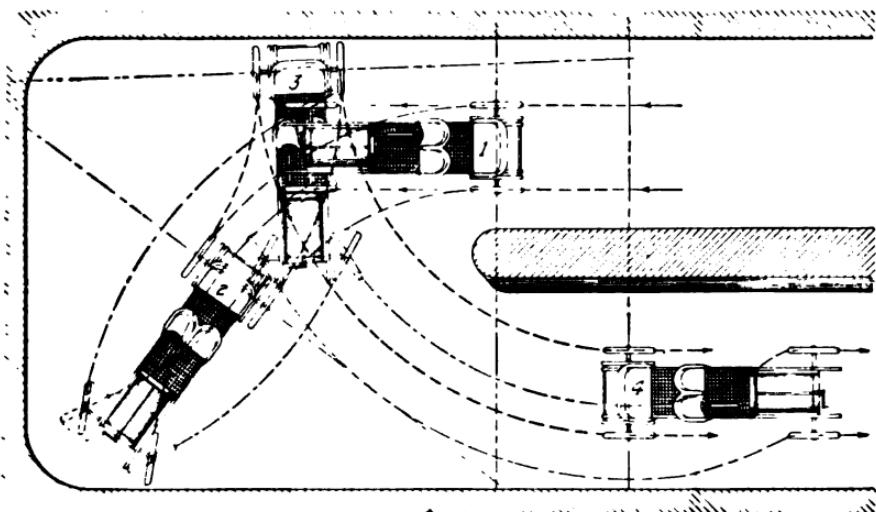


Fig. 44. Maneuvers in Getting Out of a Blind Court

Supposing, however, that he did not warp his front wheels over enough on the first backing, position 2, in order to get into the favorable position at 3; or supposing that even in position 3, he could not clear the opposite curb; then backing again would have been necessary, adding positions 5 and 6. Supposing, moreover, that the street had been much narrower than the one shown, relative to the size of the car; in that case, it might have been necessary to back as many as four or five times, instead of once as shown.

In such a case as this last, where every inch counts, skill in backing and zigzagging is worth a great deal, and this can be obtained only by practice. The situation shown is a very simple one, not in any sense a difficult or hazardous turn.

Volumes could be devoted to this subject, for the situations met with on the road are endless, as are also the combinations of cars, drivers, and corners. The driver should always be fair and render to others their half of the road, their share of time wasted and saved, as well as consider that they might have been as near right as he.

Use of Blue Books, Road Guides, Etc. Many persons never learn to use maps, road guides, and similar touring helps, but must stop to ask questions at every turn in the road, every cross road, and every situation which is not self-evident. This makes touring, especially long-distance touring a nuisance, for many reasons. First, the information obtained from farmers and country people is hardly ever accurate. Strange as it may seem, such people seldom have any correct idea of distances, of exact turns to the right or to the left, of accurate location of cross roads, or, in general, can give any precise and dependable information.

In addition, many times the turn or cross road comes in an isolated spot where there are no people to give information; then making the wrong selection may mean retracing many miles of running. In general, the driver can note the trend of travel; that is, the surfaces of two intersecting roads or a road and a turnout will show which is used the most. As soon as a driver gets to noting road surfaces in this way, he gets onto picking out the main road at all times, and in a few years of driving will cross an entire State without looking at a map or guide.

However, for those who never acquire this skill, it is well to know how to handle some form of guide. Whenever a tour is planned, the general route should be considered and settled first; then it is time to proceed to the details, side trips, precise sections of road to be covered, etc. In using a Blue Book, for instance, in the front of each volume there is a large map of all the territory covered. On this the driver should sketch out in a general way his course. Then, there are smaller maps showing more details of the various sections. The driver should go over these, amplifying his first plan, and noting down the specific route numbers which can be followed, noting both or all where more than one way is possible.

Next in order, he should read through the route directions, as per the route numbers he has just jotted down, choosing as he does

so, the one he prefers—where there is a choice. Having completed this for entire distance, so as to have a total route from starting point to destination, he should figure out the mileage total, and from this work out a rough plan of each day's task. In this, it should be considered that with existing speed laws and considering general road conditions in the United States, 150 to 200 miles constitute a good day's work, with 165 as a fair average. This done, a separate notation for the driver's pocket should carry all the route numbers in the order followed. One person should read the Book directions to the driver, reading in advance, so he can anticipate turns, etc.

MOTOR TOURING INFORMATION

Requirements in the States. In Table II will be found the principal information relative to the legal requirements in the various States, as in force at the end of 1914. In this, it will be noted that with the exception of five States, the entire country is now available to the motorists possessed of a car and license in his home State. The exceptions are: Delaware, where an additional license is issued without charge; Oklahoma, where the new license costs but \$1; South Carolina, where the same situation exists; Tennessee, where the new license will cost \$3; and Texas, where it costs 50 cents. As will be noted in Table II, while there are wide differences in the various laws, in so far as the non-resident tourist is concerned there is little or nothing to give him either trouble or delay.

Requirements in Canada. Practically the same is true of Canada, three of the eastern provinces, Quebec, New Brunswick, and Nova Scotia, permitting those to enter free who have complied with the provisions of the law in their home Province or State. Ontario requires a license, taken out at Toronto with the Provincial Secretary at \$4 for the year and also chauffeur's license at \$1, these being exacted in case the tourist is not known personally to the officer at the border. In the latter instance, if the tourist is known, he may be allowed to enter free of both tax and duty for seven days. As to duty, if the stay is to be for less than six months, a bond for twice the amount of duty can be given. This is furnished by bonding companies in the principal cities and usually at the border line, for a fee of \$5.

The following will furnish such a bond: *Guarantee Company*

TABLE II
Automobile Laws of the Various States

State	To Be Registered and Where	Registration Fee	Certificates and Tags	Driver's Fee and Badge	Age of Driver	Exemption Non-Residence	Licensing Year	Speed Limits City Country	Fine for Speeding	Lights	
										Oct. 1-Sept. 30	Jan. 1-Dec. 31
Alabama	Car, Owner and Chauffeur	\$1.50 to \$25 \$5 to \$10	One Tag Certificate and Two Tags	\$5 Badge No Prov.	16	Reciprocal Exempt 6 Mos.	15	30	\$25	Standard*	Standard*
Arizona	Car, Owner and Chauffeur	\$10	Certificate, Seal and One Tag	\$1 Badge No Prov.	18	Exempt	15	20	Not Over \$200	Two White Front	Two White Front
Arkansas	Car, Owner and Chauffeur-A	\$2 to \$30	Certificate and Two Tags	\$2 Badge No Prov.	Exempt 3 Mos.	Year from Date Issue	15	30	Not Over \$100	Standard*	Standard*
California	Car, Owner and Chauffeur	\$2.50 to \$10	Certificate and One Tag	\$1 Badge No Prov.	Exempt 90 Days	Jan. 1-Dec. 31	No Provision	\$25 to \$250	Standard*	Standard*	Standard*
Colorado	Car, Owner and Chauffeur	\$0.50 to \$10 h.p.	Two Tags	\$2 Plate Certificate and Tags	18	Reciprocal License, no fee Reciprocal 30 Days a Year	Jan. 1-Dec. 31	25	Not Over \$500	Standard*	Standard*
Connecticut	Car and Operator	\$5	Certificate and Tags	\$5 \$2	16 No Prov.	16 30 Days a Year	Jan. 1-Dec. 31	20	\$10 to \$200	Front and Rear	Front and Rear
Delaware	Car and Owner-B	\$5	Certificate and One Tag	\$2	No Prov.	Perpetual Perpetual Perpetual	Jan. 1-Dec. 31	20	No Provision	Front and Rear	Front and Rear
District of Columbia	Car, Owner and Operator	\$15 to \$40	One Tag	No Prov.	16	30 Days a Year	Jan. 1-Dec. 31	25	Not Over \$200	Front and Rear	Front and Rear
Florida	Car and Owner-B	\$4 to \$10	Certificate and Tag	No Prov.	16	30 Days a Year	Jan. 1-Dec. 31	30	Not Over \$300	Front and Rear	Front and Rear
Georgia	Car and Owner	\$2	Two Tags	No Prov.	16	30 Days a Year	Jan. 1-Dec. 31	25	\$200	Front and Rear	Front and Rear
Idaho	Car and Owner-A	\$15 to \$40	Certificate and Tag	No Prov.	16	30 Days a Year	Jan. 1-Dec. 31	30	Not Over \$300	Front and Rear	Front and Rear
Illinois	Car, Owner and Chauffeur	\$4 to \$10	Certificate, Seal and Two Tags	\$5 Badge No Prov.	16	30 Days a Year	Jan. 1-Dec. 31	25	Not Over \$300	Front and Rear	Front and Rear
Indiana	Car, Owner and Chauffeur	\$5 to \$20	Two Tags	\$2 Badge No Prov.	18	Reciprocal	Jan. 1-Dec. 31	10, 15, 20, 25	\$100	Standard*	Standard*
Iowa	Car and Owner	\$15	Certificate and Tag	No Prov.	16	Reciprocal 30 Days	Jan. 1-Dec. 31	25	Not Over \$100	Standard*	Standard*
Kansas	Car and Owner	\$5	Certificate and Tag	No Prov.	14	30 Days	July 1-June 30	12	Not Over \$100	Front and Rear	Front and Rear
Kentucky	Car, Owner and Chauffeur	\$5 to \$20	One Tag	No Prov.	16	Exempt 30 Days	Year from Issue Jan. 1-Dec. 31	10 & 15 20	Not Over \$100	Front and Rear	Front and Rear
Louisiana	Car, Owner and Operator	\$5 to \$15	Certificate and Two Tags	\$2	18	Reciprocal to 90 Days	Jan. 1-Dec. 31	10 & 15	Not Over \$50	Standard*	Standard*
Maryland	Car and Owner-B	\$5 to \$25	Certificate and Two Tags	Oper. \$2 Chauf. \$5	16	2 Non-Contiguous Weeks 10 Days	Jan. 1-Dec. 31	18	Not Over \$200	One White Fr., 1 Red Rear	One White Fr., 1 Red Rear
Massachusetts	Car, Owner and Operator-A	\$5 to \$25	Certificate and Two Tags	\$2	16	Reciprocal to 90 Days	Jan. 1-Dec. 31	15	Not Over \$100	Standard*	Standard*
Michigan	Car, Owner and Chauffeur	\$0.50 h.p.	Certificate and Two Tags	\$2 Badge	18	Oper. \$2 Chauf. \$5	Jan. 1-Dec. 31	20	Not Over \$100	Front and Rear	Front and Rear
Minnesota	Car, Owner and Chauffeur	\$1.50	Two Tags	\$2 Badge	Oper. \$16 Chauf. \$18	30 Days	Jan. 1-Dec. 31	15	Varies	Standard*	Standard*
Missouri	Car, Owner and Chauffeur	\$3 to \$12	Certificate and One Tag	\$1.50 Badge	18	30 Days	Every 3rd Yr., Feb. 1-Jan. 31	25	Not Over \$100	Standard*	Standard*
Montana	Car and Owner	\$2	Certificate and Tag	\$2 Badge No Prov.	Perpetual	Exempt	Perpetual	\$50 and \$100	Front and Rear	Front and Rear	Front and Rear
Nebraska	Car and Owner	\$0.125 h.p.	Certificate and Tag	\$16 Seal and One Tag	16	30 Days	Year from Issue Jan. 1-Dec. 31	12	Not Over \$100	Front and Rear	Front and Rear
Nevada	Car and Owner	\$2.50 Min.	Certificate and Two Tags	\$5 Badge Oper. 16 (Chauf. 18)	16	30 Days	30 Days	25	Not Over \$100	Standard*	Standard*
New Hampshire	Car, Owner and Chauffeur	\$10 to \$40	Certificate and Two Tags	\$5 Badge Oper. 16 (Chauf. 18)	16	10 Days	Jan. 1-Dec. 31	15	Not Over \$100	Standard*	Standard*

TABLE II—Continued

State	To Be Registered and Where	Registration Fee	Certificates and Tags	Driver's License and Badge	Age of Driver	Exemption—Non-Residence	License Year	Speed Limits		Fines for Speeding	Laws
								City	Country		
New Jersey	Car, Owner and Operator—C	\$4.50 to \$15	Certificate and Two Tags	\$2 to \$4 Certif.	16	Recipient, 16 D.	Jan. 1-Dec. 31	12	25	Not Over \$100	Standard*
	Car and Owner	\$2 to \$12	Tag, Certificate and Tag	No Prov. No Prov.	14	60 Days Reciprocal	Jan. 1-Dec. 31	No Prov.		No Provision	Standard*
	Car, Owner and Chauffeur	\$5 to \$25	Certificate and Two Tags	\$5 Badge	18	Recipient	Feb. 1-Jan. 31	R & P	30	Not Over \$50	Standard*
	Car and Owner	\$5 to \$10	Tag, Certificate and Tag	No Prov.	16	Recipient	July 1-June 30	10 & 15	25	Not Over \$50	Standard*
	Car and Owner	\$3	Certificate and Tag	No Prov.	10	Exempt	Jan. 1-Dec. 31	10	30	Not Over \$50	Standard*
	Car and Owner	\$1	Certificate	No Prov.	Not Exempt	Jan. 1-Dec. 27	No Limit			No Provision	No Provision
	Car, Owner and Chauffeur	\$3 to \$18	Two Tags	\$2 Badge	18	30 Days	Jan. 1-Dec. 31	25	Not Over \$50	Standard*	
	Car, Owner and Chauffeur—A	\$5 to \$15	Certificate and Two Tags	\$2 Badge	18	10 Days a Year	Jan. 1-Dec. 31	24	\$10 to \$25	Standard*	
Oregon	Car, Owner and Chauffeur	\$5 to \$25	Certificate and Two Tags	\$1	16	20 Days	Year from Issue	15	25	Not Over \$500	1. White Front Red Rear
Pennsylvania	Car, Owner and Chauffeur—A	\$1	Certificate and Two Tags	No Prov.	Not Exempt	Perpetual	Jan. 1-Dec. 31	15	\$10 to \$100	Front and Rear	
Rhode Island	Car, Owner and Operator—D	\$1	One Tag	No Prov.	15	Reciprocal	Perpetual	25	Not Over \$50	Standard*	
So. Carolina	Car and Owner—E	\$3 or \$6	No Tag	No Prov.	Not Exempt	Perpetual	Perpetual	25	\$25 to \$100	No Provision	
South Dakota	Car and Owner—E	\$3	Certificate and Tag	No Prov.	Not Exempt	Perpetual	Perpetual	20	\$25 to \$100	One Lamp	
Tennessee	Car and Owner	\$3	Certificate and Tag	No Prov.	Not Exempt	Perpetual	Perpetual	18	\$25 to \$100	Standard*	
Texas	Car and Owner—E	\$0 to 50	Seal and One Tag	\$2 Badge	Not Exempt	Perpetual	Perpetual	20	Varies	Standard*	
Utah	Car, Owner and Chauffeur	\$2	Seal and One Tag	No Prov.	Perpetual	Perpetual	Perpetual	10 & 15	Varies	Standard*	
Vermont	Car, Owner and Operator	\$1 a. h. p.	Certificate and Two Tags	\$2 Badge	No Prov.	Recipient	Year from Issue	10	25	Not Over \$50	Standard*
Virginia	Car, Owner and Operator	\$5 to \$20	Certificate and One Tag	\$2 50	No Prov.	2 Non-Contiguous Weeks	Jan. 1-Dec. 31	8	20	Not Less than \$10	Standard*
Washington	Car, Owner and Operator	\$2	Certificate and One Tag	\$2 Badge	No Prov.	Exempt	June 1-May 30	12	24	\$100	Ft. and Red Rear
West Virginia	Car, Owner and Chauffeur—F	Car is Taxed	Two Tags	\$2 Badge	No Prov.	Recipient	Perpetual	10 & 15	20	Not Over \$100	Standard*
Wisconsin	Car and Owner	\$5	Certificate and Tags	Local Prov.	16	Exempt	Jan. 1-Dec. 31	15	25	Not Over \$100	Pt. and Red Rear
Wyoming	Car and Owner	\$4	Certificate and Tags	No Prov.	15	Exempt	Jan. 1-Dec. 31	Reasonable		Not Over \$100	Front and Rear

Louisiana is the only State that has no law. Mississippi and Ohio laws have been declared invalid and not replaced by new (on Dec. 1, 1914). All cars are registered with Secretary of State, except as follows: A, with Highway Commissioners or Dept.; B, with Commissioner of Motor Vehicles; C, with Assistant Secretary of State; D, with State Board of Public Roads; E, with County Clerk; F, with State Auditor.

* The Standard lamp equipment is two white lamps in front and one rear lamp showing a red light.
† The same as the standard except that license numbers must be shown in the lamps.

of North America, 111 Broadway, New York City; J. A. Newport & Company, Niagara Falls, Ontario; Niagara Falls Auto Transit Company, Niagara Falls, New York; J. M. Duck, Windsor, Ontario; A. J. Chester, Sarnia, Ontario; F. W. Myers & Company, Rouse Point, New York, and Alburt, Vermont.

Messrs. Newport and Duck will also procure the license and permit in advance, if requested, the charge being \$4.30 (\$4 fee, 30 cents postage).

The speed regulations in Canada are about the same as in the States; New Brunswick provides 12 m.p.h. in cities and towns, 15 in built-up continuous territory, and 20 in open country; Nova Scotia, 7½, 12, and 15; Quebec, reasonable and proper, 12 in built-up sections and 15 miles elsewhere; Ontario, 15 within city limits and 20 elsewhere.

Touring Books and Maps. There are five volumes of the Blue Book as follows: Vol. 1, New York State and Lower Canada; Vol. 2, New England and the Maritime Provinces of Canada; Vol. 3, New Jersey, Pennsylvania, Delaware, Maryland, District of Columbia, and Southeastern States; Vol. 4, the Middle West; Vol. 5, Mississippi River to the Pacific Coast.

Aside from these there are a number of excellent guides, maps, and books which will be of assistance to the motoring roamer. The Blue Books are published by the Automobile Blue Book Publishing Company, 2160 Broadway, New York City, and 910 S. Michigan Avenue, Chicago, Illinois, at \$2.50 a volume. These are endorsed by the American Automobile Association, and its members get them at a special price.

The Automobile Club of America also publishes a tour book which is sold to the public at \$3.00 but is free to members of the Bureau of Tours. The Blue Book Company also gets out the Pilot maps, covering the New England States and the Hudson River district; these consist of large scale maps only, with no text. C. S. Mendenhall, Race Street, Cincinnati, Ohio, publishes automobile maps, of some 20 or more States, while similar maps of the Western States are gotten out by the Clason Map Company, Denver, Colorado. Some of the middle Western States are covered by a series of large scale maps published by the Iowa Publishing Company, Des Moines, Iowa. Colorado maps are given away by the Denver

and Colorado Springs Chambers of Commerce; other free maps or guides are those of Maine, Maine State Automobile Association, 12 Monument Square, Portland, Maine; Motor Tours in Nova Scotia, by the *Halifax Morning Chronicle*; the Goodrich Tire Company of Akron, Ohio, issues a set of maps covering most of the country, etc. For those who can use them, the topographical maps of the U. S. Geological Survey are very interesting and most accurate, giving more detailed information than any others. Information relative to them can be obtained from the Director of the Survey, Washington, D. C.

Foreign Touring Books. The Michelin and Continental Tire Companies furnish excellent route books covering practically all of Europe, Northern Africa, and Western Asia, which is tourable. Other excellent foreign publications along this line are *Le Guide Taride* for France, Italy, and Switzerland; Bartholomew's Strip Maps of England; Mittlebach's Road Maps of Germany and Austria; the *Carte Routiere Dion-Bouton*, and the most excellent works of the *Touring Club de France*, usually spoken of as the T. C. F., as well as the automobile clubs of Italy and Switzerland.

Foreign Licenses. *Triptyque.* By joining the T. C. F. at 6 francs a year (about \$1.25), the motorist will be saved all the trouble and delay of arranging for a deposit to cover customs duties, the issuance of the triptyque, etc. The latter is in substance a pass for the country issuing it, and under the newest arrangement, one pass covers practically the whole of Europe. Formerly, there were many countries which did not issue them, in which case the customary deposit in gold was required at each one; in addition, a number of different ones were necessary for the various countries. The new customs pass book, which is printed in French, with explanatory notes in every European language, is good in 13 countries, the deposit covering only the highest duty in the group—Spain, Austria, or Sweden—according to the car. When entering the first foreign country, the customs officer tears out one of the pass-in checks and gives a marginal receipt for it. On leaving that country, a pass-out check is withdrawn and signed for in the same manner.

One advantage of this new arrangement, which went into force in 1914, is that it allows the holder to pass over a frontier any number of times—formerly impossible or at least difficult enough to dis-

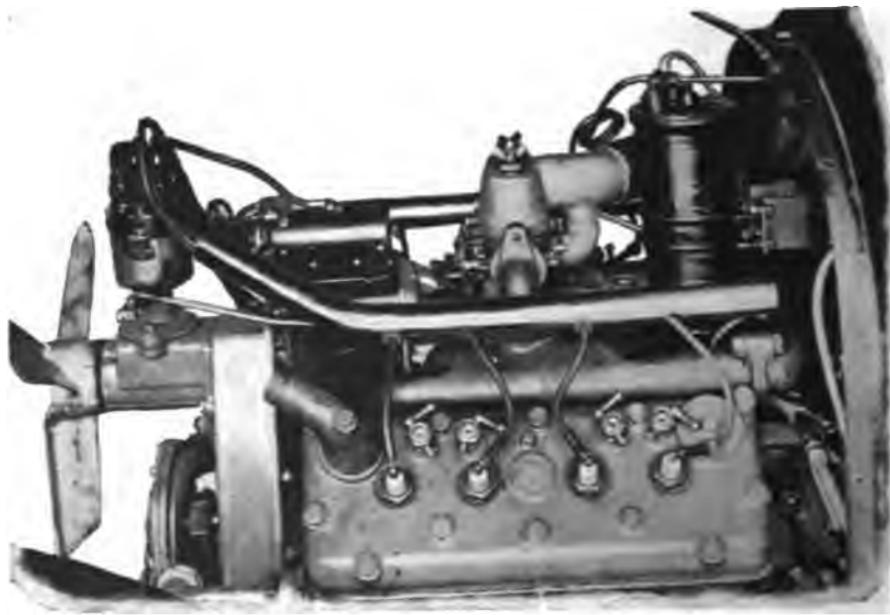
courage the driver who tried it. The new triptyque is good in France, Switzerland, Belgium, Italy, Spain, Sweden, Austria, Russia, Hungary, Denmark, Holland, Norway, and Roumania. Although Great Britain is not a party to this arrangement, there is no duty for that country.

International Driving and Car License. Complementary to this is the International Driving and Car license, which has been in use several years and is recognized by 17 European countries and several English and French colonies. To secure both the triptyque and the driving license, it is necessary to obtain before starting from home, a letter from the manufacturer of the car, giving the name of the maker, model (year), style, number, color of body and chassis, make of tires, number of seats (places), weight, value, number of motor, number of cylinders, motive power, horsepower, together with the owner's name and address. Two small, unmounted photographs of owner and operator are necessary.

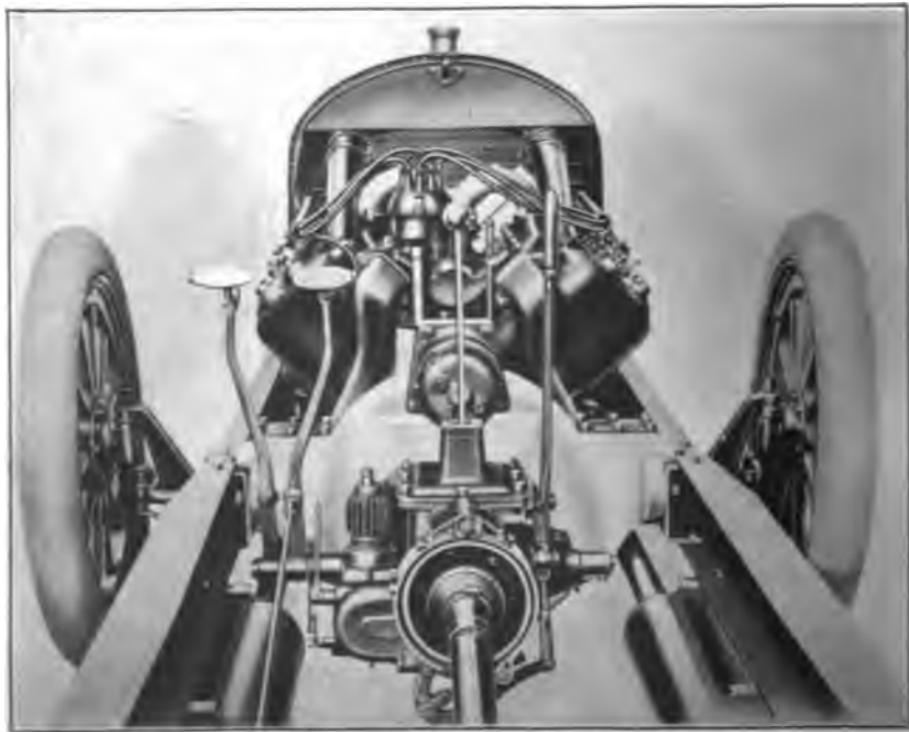
Shipping and Other Information. Much of the detail of shipping the car can be done by correspondence, if the car owner is a member of either the A.A.A. or the A.C.A. Shipment has been much simplified in recent years, and a number of custom-house brokers have entered this field. Consequently, it is a simple matter to turn the whole business over to one of these. He will attend to all details, such as the crate, the lighterage, if any, storing the crate abroad, ocean freight, dock charges, custom charges if any, etc., handling this for a lump sum. The American Express Company is an authorized forwarding agent for the A. A. A., while Oelrichs and Company, Bowling Green Building, New York, the general agents for North German Lloyd Company, have a special department to take care of this for the tourist. The International Mercantile Marine, including the White Star, American, and Red Star lines, also has a special department for this.

American Customs Arrangements. In addition to all this, the owner's car must be registered at the Custom House in New York, or other point of departure, to obtain outward bound clearance. Before returning to America, the tourist must obtain from the American Consul at the point of departure, an inward bound clearance and a declaration must be made before the consul that the car was exported from America. A customs broker will attend to this.

In general, the tourist should plan his tour in advance, laying it out as accurately as possible, including the roads, stops, hotels, daily mileages, etc. It is almost a necessity to arrange for passage over and back, for both owner and car, well in advance. Fuels, oils, etc., are about twice and from that to three or four times as much as in this country, but garage charges for repair work, adjustments, washing, storage, etc., are less than half the similar charges in the United States. The roads are good, and while the regulations call for low speeds, with the maximum around 15-18 m.p.h., these are seldom enforced and the average speed in the country is very high.



OLDSMOBILE "LIGHT" EIGHT-CYLINDER MOTOR
Courtesy of Olds Motor Works, Lansing, Michigan



EIGHT-CYLINDER KING MOTOR, MOUNTED IN CHASSIS
Courtesy of King Motor Car Company, Detroit, Michigan

TROUBLES AND REPAIRS

PART II

ENGINE AND ACCESSORIES

OVERHAULING THE ENGINE

General Instructions. The engine should receive the greater portion of the time and attention during any repair or overhaul



Fig. 1. Dismounting the Engine for Repair

work, going so far as to take it out of the chassis if the trouble is at all serious. For this purpose, all ignition wires and carbureter and magneto operating rods are detached. Next the various manifolds are removed, the water system is drained, and all hose connections are broken. Usually it is necessary also to take the radiator off, in which condition the appearance of the vehicle and the work is very much like that presented in Fig. 1.

When all accessories have been removed or loosened up, the

holding bolts are taken out, and the clutch disconnected, leaving the motor free to be swung out by means of a small crane or hoist. In some cases, the work can be completed without disturbing the base of the motor, as in Fig. 2, which shows a big car partly disassembled for repairs, the radiator and cylinders being off at this stage. The trouble here was found within the cylinders, hence, as soon as they had been removed, the balance of the six-cylinder motor and its chassis could remain undisturbed.

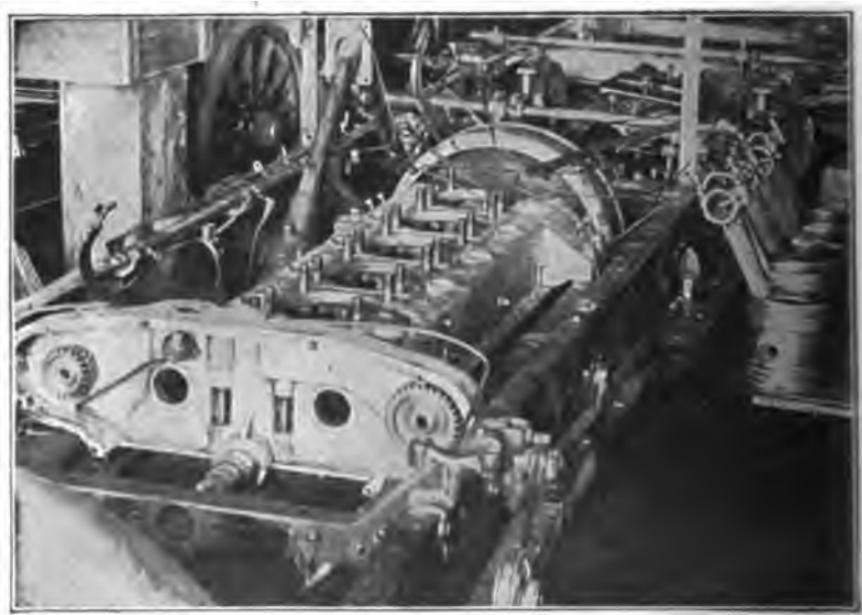


Fig. 2. Engine Dismounted Showing Cylinders Removed

PISTONS

Carbon Deposits. Cleaning an engine of carbon represents a very dirty job, one that is shirked as much as possible. The novice should learn the cause of formation of carbon deposits in the cylinders, and by avoiding this, get out of doing this dirty work. In addition, credit will attach to him for a better running engine. Carbon deposits are formed by the partial combustion of the excess of fuel or lubricating oil. To run with too little oil sounds like bad advice, but it will cure the sooting trouble, and should be practiced as soon as the driver becomes proficient enough to "monkey" with those things.

The most important thing to learn about the formation of carbon is that it is caused by incomplete combustion, which also means fuel going to waste. Hence the motor should be cleaned and then run so as to consume the fuel completely, and thereby prevent the formation of scale in the future. This can be effected by proper care in selecting the oil used for lubricating the cylinders, the method of lubrication, and amount of oil fed in. Also, care must be exercised in the selection and use of the fuel, particularly the latter, as this may, in extreme cases, be such as to deposit particles of carbon



Fig. 3. Removing Carbon with File

in the cylinders. Care in this direction is well invested, however, as any autoist who has ever dismantled his engine can testify.

Carbon sometimes collects in the muffler, the effect of which may be illustrated by the following: In case of one automobile, it collected there until there was a large quantity of it, sufficient to obstruct the passage of the heated gases. The immediate effect was to heat up the muffler pipe until it was red-hot. This, in turn, transmitted its heat to the exhaust pipe which became red-hot. Finally this reached the cylinders, and the whole exhausting system

beyond the cylinders was red-hot. The owner and driver of the car was at his wit's end to find the trouble, seeking it in the carburetion and ignition systems, of course without result. After working on the trouble unsuccessfully for some weeks, he accidentally hit the muffler a sharp blow. The amount of dirt which fell out surprised him so much that he was induced to take the muffler off. Finding it very full of carbon, he cleaned it and put it back on the machine and no more trouble with hot pipes was experienced.

Removal of Carbon. When the offending inember has once been brought out so it can be handled, the removal of the carbon can be accomplished in a few minutes. As shown in Fig. 3, the scraper is made from an old file, flattened out at the end, and ground down so as to present one sharp edge. Every owner should accumulate from five to a dozen shapes and sizes of scrapers for various work, including a flexible one with which to reach into corners, etc. A flat piston head like that shown can be scraped off with any knife or chisel, but a special tool is better. The carbon is brittle and comes off readily, after which the surface should be filed or rubbed over with emery and oil to make it smooth, in order to delay the formation of a second coat. This is true of carbon in other places, but usually it is impossible to smooth the surface, in which case the process must stop when the part is scraped clean.

Another method of removing carbon is the introduction of a metal object, as a ball or a piece of chain, which the piston is allowed to bounce up and down, the object being to break up the carbon.

A better way is to couple up a number of short lengths of chain—old tire chains will do—and attach them to the flexible shaft of a buffing or polishing outfit, as shown in Fig. 4. This chain and shaft end can then be introduced into the combustion chamber and, when the current is turned on, the rotation breaks off all carbon.

Nowadays, however, most of the carbon removal is done by means of liquid solvents. Of these, kerosene, denatured alcohol, and special preparations are the most widely known and used. Kerosene is used when returning from a trip. Just before stopping the engine, it is speeded up and a little kerosene inserted into each cylinder. This loosens the carbon so it blows out through the exhaust.

Denatured alcohol and also the special preparations are used in much the same way, except that the engine is not run. After

returning to the garage and while it is still hot, an ounce or so is placed in each cylinder and left to stand there over night. On starting the motor the next morning, the loosened carbon is blown out through the exhaust pipe. If the carbon is very thick, more alcohol must be used and allowed to stand for a longer time. By repetition, this will gradually clean out all there is in the cylinders.

Removal and Replacement of Pistons. Speaking of pistons, there are several things that the beginner should learn about their removal and replacement. While it is not a difficult matter to pull

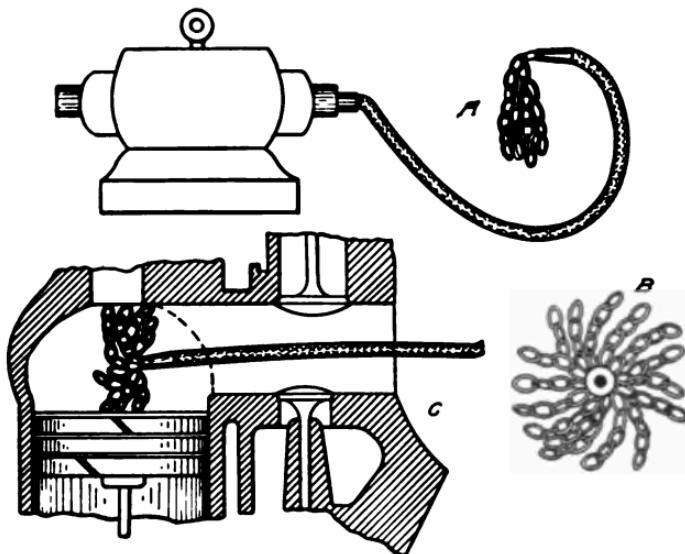


Fig. 4. Removing Carbon with Flexible Shaft and Old Chain.
 (A) Motor, Shaft and Chain. (B) Method of
 Assembling Chain. (C) Device in Use

a piston out of a cylinder, when both have been previously lubricated, and all proper precautions taken to loosen connecting parts, there are a few important things to remember.

The piston should be drawn out as nearly parallel to the axis of the cylinder as is possible, accompanied by a twisting motion not unlike taking out a screw, in case it sticks a little. If the piston sticks badly, pour in a little kerosene and work the piston in and out so as to distribute the kerosene between the two surfaces.

To get at the spaces, the rings must be removed, and as they are of cast iron and very brittle, this is a delicate task. Two methods of accomplishing this is illustrated in Fig. 5. If the owner has a pair of ring-expanding pliers, the rings can easily be

expanded enough to lift them over the edge as shown in (a). As very few owners possess this useful tool, however, a more common way is shown in (b). Secure a number of thin, flat steels about $\frac{1}{2}$ inch wide and $\frac{1}{16}$ inch thick, corset steels, flat springs, or hack saw blades may be used, although the latter require more care on account of the teeth along one edge. The length of these steels should be such as to reach from about an inch below the last ring to the top. Lift out one side of the ring with a small pointed tool and slip one

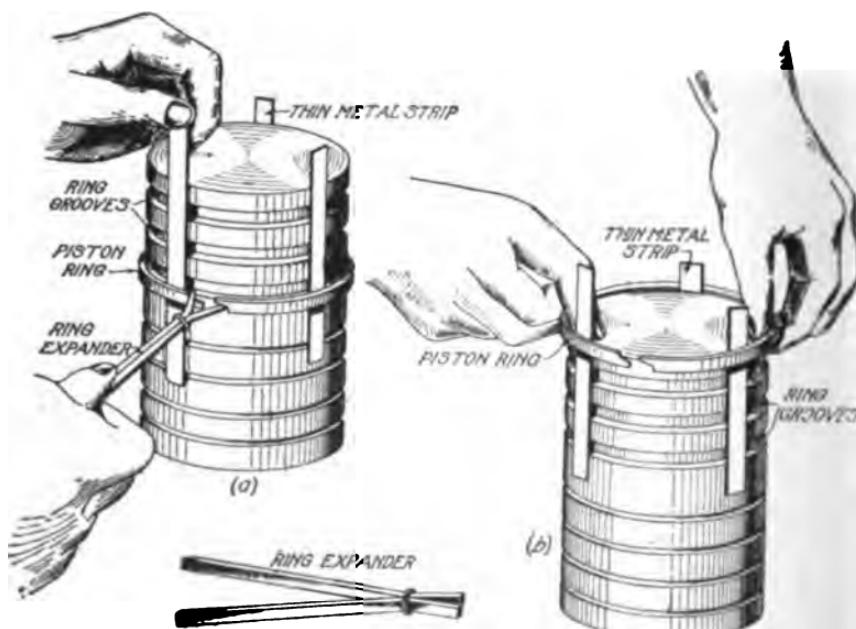


Fig. 5. Method of Removing Piston Rings

of the steels between the ring and the piston; then move around about $\frac{1}{3}$ of the way and insert another, taking care to hold the first in place; repeat the operation with a third steel. When these are in place the steels will hold the ring out from the piston enough so it may be slid over the "lands" between the grooves, and along the steels to the top.

Always begin at the bottom, working up, when removing rings, and just the opposite, from the top down, when replacing them. After one is mastered, the removal of the others is a simple matter of repetition. The grooves can now be scraped free of the offending

carbon, a process which is but an inversion of the previous method, after which it will be necessary to replace the rings.

Replacing the piston in the cylinder is a more difficult operation. There are two ways of doing this, viz, by a special form of ring closer, and by hand, using a string. The former is a shaped device which is clamped around the ring and squeezed together with pliers, using one hand, while with the other hand the ring is guided into the groove. The second and more usual method is illustrated in Fig. 6,



Fig. 6. Method of Re-Assembling Piston Mechanism

and requires two men, unless the cylinder is of such a shape that it can be clamped in a vise. As the picture brings out, one man holds the cylinder while the other forces the piston carrying the rings into place. The piston is shoved in until the expanded top ring prevents further movement, when a heavy cord is placed around the spring, and the ends are crossed, thus closing up the ring and allowing the piston to slide in as far as the next ring. The operation is repeated successively for the other rings. This is a very simple method and requires only patience.

Proper Method of Bolting on Head. Usually on an L-head type of motor, there are three rows of bolts for the cylinder head—one row along the middle, screwing into one side of the cylinders; another row screwing into the other side of the cylinders; and a third along the valve side. These should be tightened in order: first the middle bolts of the middle line, working out to the ends; next, in turn, the middle bolts of the back of the cylinder, the middle bolts of the valve side, the ends of the cylinder, and, finally, the end bolts on the valve side. All these should be tightened but a few turns at a time, and after all are down, a second round should be made in about the same order, to give each bolt a few more turns. In this way the cylinder head casting, which is both large and intricate, is slowly pulled down to the cylinder straight and true so that it is not warped or twisted. Moreover, if the cylinder is pulled down straight in this manner,

all the bolts can be tightened more than if the first bolt were tightened very much, for this latter method would result in cocking up the opposite side so that the bolts could not be properly tightened.

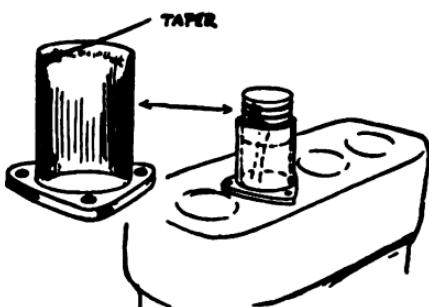
Rigging for Replacing Piston.

In motors with detachable head, like the Willys, Chalmers, Briscoe, and others, the work of

Fig. 7. A Simple and Easily Made Jig for Replacing Pistons in Detachable Head Motors

replacing pistons, particularly if the crank case is cast integral with the cylinder block, is considerable. In fact it is sufficiently difficult to warrant making a special jig for guiding the pistons down into the long cylinder bores.

As shown in the sketch, Fig. 7, the jig consists of a round shell, the interior of which is at the bottom of the same bore as the cylinder, but flares out considerably at the top. The base consists of the flange needed for turning this in the lathe, and may be of any shape, size, and thickness. The action of the enlarged diameter at the top, gradually reducing to the exact cylinder size at the bottom, is to hold the piston rings in place and slowly contract them as the piston is lowered, so they pass down into the cylinder bore without trouble. One casting must be made for each cylinder bore, but the



time and trouble which they save and the injuries to workmen and parts which they avoid make them well worth while.

Speeding up Old Engines by Lightening Pistons, Etc. As has been pointed out previously under Cams, one way to speed up an old engine is to replace the old camshaft and cams with new ones giving more modern timing. Another and a less expensive and troublesome way in which this can be done is by lightening the pistons and reciprocating parts. This the repair man will surely be called upon to do, as the manufacturer probably would refuse.

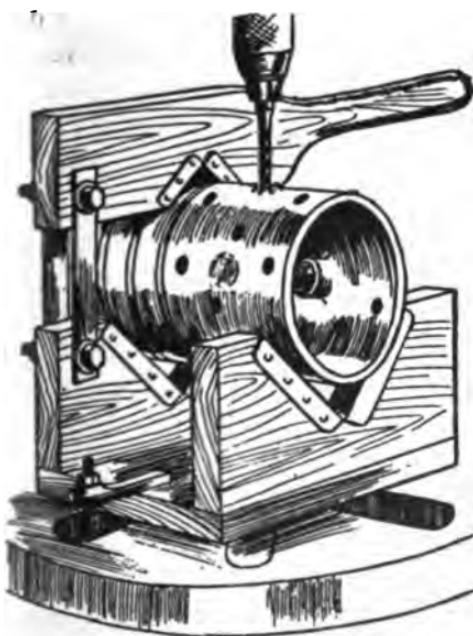


Fig. 8. A Home-Made Wooden Stand to Facilitate Drilling Out Pistons

8, to keep the piston from turning, so that it will not break the drill. A good way to begin is to construct a base with a pair of uprights having deep 90-degree V's in them, this being made so that it can be bolted to the drill-press table. The V's should be lined with leather or fabric, and for this purpose discarded clutch or brake linings answer very well. To one of the uprights is pivoted a long handle, having a lined V which matches with that of the upright below it and gives a good grip on the piston.

Drilling Holes. When drilling to save weight, the holes are put in close together, and in regular form, the idea being to take out

In order to get out any amount of metal worth the trouble, it will be necessary to drill from 12 to 20 or more holes of from $\frac{1}{2}$ -inch up to 1-inch diameter, depending upon the size of the piston as to bore and length. In a six-cylinder motor, this amounts to almost 100 holes (even more in some cases), and as these must be drilled with considerable similarity in the pistons, it is well worth while to construct a fixture to aid or speed up this work.

Clamp for Pistons. The first requisite is a clamp, Fig.

as much weight of metal as is safe. In doing this it is well to work out a scheme of drilling in advance and to make a heavy brown paper template, fastening this to each piston in turn. It is not advisable to remove in the first instance all the metal possible, but only enough to show the benefit of the method; after it has proved satisfactory, the first job may be improved upon later. For instance, in lightening pistons it is a good plan to use a $\frac{3}{4}$ -inch drill the first time and not to put in too many holes. If this proves satisfactory and the owner comes back for more, you can go over the same lot of pistons, using a $\frac{1}{2}$ -inch or $\frac{3}{8}$ -inch drill between the existing holes, and thus reducing the weight of the lower end of the piston to its lowest possible point.

Curing Excessive Lubrication. *Holes in Cylinders.* When it comes to drilling holes, to provide an outlet for the excess oil in the cylinders and so to reduce smoking, small holes, $\frac{1}{4}$ -inch for example, are sufficient and may be drilled in on any spiral plan, simply beginning near the bottom and working up close to the piston pin bosses along a spiral track. The advantage of the spiral arrangement is that no hole is above another; the dripping from each hole is therefore distinct and the quantity which runs down is greater.

Grooving Pistons. Another method of curing the excessive lubrication to which the older cars—particularly those with splash lubrication—are subject, is to turn a deep groove in the bottom of the piston, about like a piston ring groove but with the lower edge beveled off. When this is done, much as shown in Fig. 9, a series of small holes—made with about a No. 30 drill—are put in at the angle of the bevel; 6 or 8 holes, equally distributed around the circumference, are probably enough. The sharp upper edge acts as a wiper and removes the oil from the cylinder walls into the groove, whence it passes through the holes to the piston interior, and there drops back into the crankcase. No ring is placed in the slot as it would prevent the free passage of the oil. This device stops the smoking immediately.

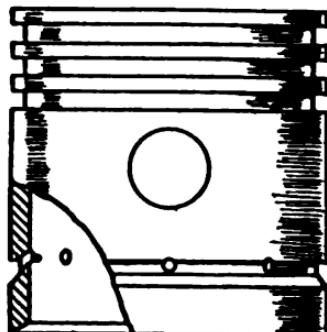


Fig. 9. Method of Grooving and Drilling Piston to Overcome Excessive Lubrication and Smoking

Piston Troubles. *Frozen or Clogged Pistons.* Sometimes, the pistons will apparently be frozen in the cylinders, particularly in very cold weather and when fairly thick oil is used. This is but a temporary trouble and can be cured by pouring in a thin oil or, better yet, kerosene. The thin oil will work more quickly if heated, and should be poured in on top of the pistons, either through the petcock, valve-cap opening, or other available opening in the top of the cylinder. Being thin—and if hot, thinner than usual—the oil will work down between piston and cylinder walls, cutting through the thicker oil which has hardened there under the influence of the cold weather, and thus will free the pistons.

Loose Pistons. Many times the pistons will wear just enough so that they are loose in the cylinder all the way around. This causes leakage of gas, piston slaps, and other similar troubles. If the owner of the car does not care to buy new pistons, or if the car is an "orphan", or if, for other reasons, pistons cannot be obtained, the clever repair man can remedy the trouble at small expense. The process consists in heating and expanding the old pistons. The heating is done in charcoal and must be done very carefully and slowly. After the pistons become red hot the fire is allowed to go out slowly, so that the piston is cooled in its charcoal bed. Sometimes as much as $\frac{1}{100}$ of an inch can be gained in this way. When the pistons are so far gone that they cannot be handled in this way, they must be replaced with new ones.

Use of Oversize Pistons with Worn Cylinders. When the cylinders have worn so as to require grinding out, or when scoring necessitates this, oversize pistons must be used. In the majority of factories having any kind of system, three oversizes are made $\frac{1}{100}$ -inch over, $\frac{1}{60}$ -inch over, and $\frac{1}{30}$ -inch over. The first provides for the initial grinding-out of the cylinder, the second for the second grinding, and the third for a lighter, final grinding. Beyond this, it is considered, the cylinder will be too thin to warrant further grinding; moreover, by the time three cylinder grindings have been lived out, the balance of the car will doubtless be too far gone to justify further cylinder repair work. Many factories, particularly those making a very light-weight car where thicknesses everywhere are kept down to the limit, allow but two oversizes, and thus, two grindings.

BEARINGS

Classes of Troubles. Bearings of the two-piece or split type give the amateur repair man as much trouble as anything; the crank shaft bearings should not be tackled until considerable repair experience has been had. In general, wear on the bearings is due to one of two causes, either a soft metal which has caused vertical wear on the inside or outside of the lower half of the bushing, or a vibrating shaft which has worn an oval hole somewhere in the length of the shaft, as at the inner or outer end.

In the former case, the height of the worn half must be reduced, which is usually done by taking off from the upper face as much metal as is needed. When this has been done either by filing or by rubbing across emery cloth wet with oil, the two halves of the bushing will approach so close together that the hole will be smaller than the shaft. This will necessitate scraping out or reboring according to the amount which has been taken off. In the case of very small amounts, this wear can be taken up by removing shims, which are small filling strips of sheet brass which hold the halves of the bushing apart and thus make the central hole larger. The sizes of these shims vary from .003 to .008 inch, several of each being used. By selecting those which are to be removed, or taking out one size and replacing with another, any variation in diameter from .001 to .025 can be remedied. Of course this method changes the hole from a round to a slightly oval hole, but this may be remedied by a very small amount of scraping.

When the second form of wear is found, that is, when the bushing is worn oval by a wobbling shaft end, the only remedy is bringing the bearing halves together as before and reboring. It may be that this operation robs the bearing plates of so much metal that they will not fit the holes in the case; or possibly the wear may have communicated itself to the case, so that the hole there is out of true. If this be slight, refilling the cases with babbitt metal or building-up may be resorted to, but if the wear is considerable, a new set of bearings is the only remedy. In building up the bearing, strips of soft metal are placed in the worn spots, after cutting or filing them to fit as closely as possible, and the bearing driven down upon them as firmly as possible. In this way, one can build up a worn crank case to answer for many thousand more miles running.

Ball and Roller Bearings. Thus far nothing has been said about other than plain bearings. Many motors are now built with ball bearings, while roller bearings are widely used on modern cars. It must not be thought that these never give trouble, or wear out. Such is not the case; improper lubricants often bring acids into the ball races and onto the balls, which eats into them. This causes wear and noise and gives much trouble. If badly eaten, either new balls or new races, or both, must be obtained. Where the condition is not bad, however, having just started, careful washing and frequent inspection will suffice.

With the taper form of roller, wear is compensated for by moving the races (or cones, as they are called on this form) toward one another. If the wear is slight, a very small movement of one cone will produce the desired adjustment.

Often, ball and roller bearings are difficult to remove and when removed, are difficult to replace. They must be put into place exactly straight and true, consequently it seldom is possible to drive them in. Where they enter a piece which is open on both ends, however, this difficulty may be removed by the use of large bolts with washers against the races or cones. Then by tightening on the nuts, the races or cones are gradually forced into place, while the nature of the process allows of guiding them in straight and true. In general, ball and roller bearings give little trouble to the repair man and none at all to the amateur.

VALVES

Valve Troubles. Valve troubles may be of three varieties: Worn or pitted seats, worn or pitted valves, and bent or worn stems or stem guides. In the latter case additional air is admitted, allowing the mixture to become more dilute than the operator realizes until the engine begins to miss fire. If the stem be at fault, this may be turned down to a smaller size, perfectly round and a new bushing with a hole of the new size fitted into place.

In case the trouble lies with the bushing, those of the one-piece type must be replaced if there is much wear; but if the wear is slight, a clever repair man can peen* the edges and considerable metal adjacent to them, so that a much smaller hole is formed, after which reboring to a tighter fit is in order.

*Force the metal nearer the center of the hole by means of a prick punch or by a pointed hammer.

Regrinding Valves. When either the valve head or seat has become worn or pitted, it must be reground as follows: Secure a small amount of flour of emery, the finer the better, and mix this into a thin paste using cylinder oil, or graphite, or both. Loosen the valve, disconnect all attachments, remove the valve cap above, and free the valve in a vertical direction. Now lift it out, place upon the seat a daub of the emery paste and replace the valve. With a large screwdriver press the valve firmly in place, at the same time rotating it about one fourth of a turn to the right and then the same amount to the left.

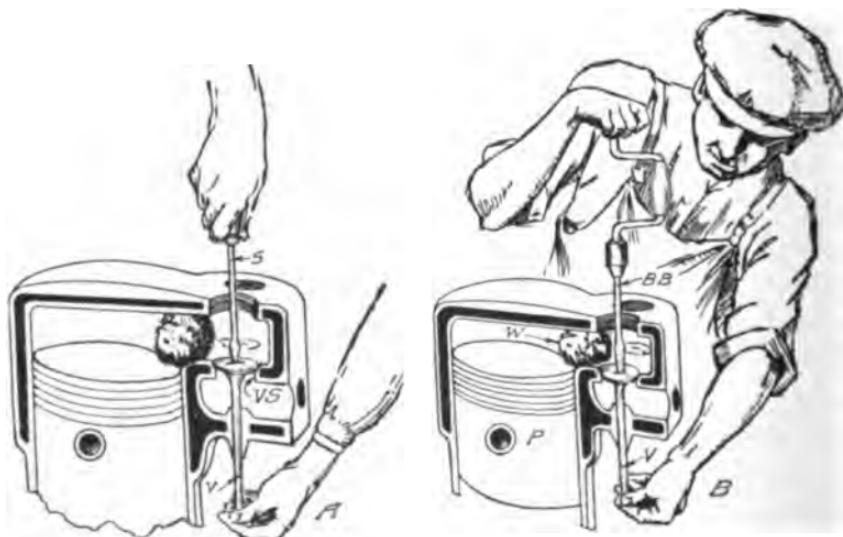


Fig. 10. Two Methods of Grinding-In Valves: (A) by Hand, Using a Screwdriver; (B) with Brace, Screwdriver and Bit

This is shown in Fig. 10-1, in which *S* is the screwdriver, *V* the valve and *VS* the valve seat. Note how the right hand presses down on the screwdriver and turns it at the same time. While this is being done, the left hand should be held right below the valve stem with one finger just touching it. After moving back and forth about eight or ten times, lift the valve off of its seat with the finger, turn it through a quarter turn, and drop it back into place. Then repeat the grinding, until the whole circle has been covered several times. Then remove the valve and clean off both moving member and seat with gasoline. With a slight touch of Prussian blue, mark the seat on the valve, replace, and twirl around several

times so as to distribute the color. Remove the valve without touching the seat portion on it or in the cylinder, and examine both. If the grinding process has been complete and accurate, the color will have been distributed in a continuous band of equal width all around the surface. If not continuous, or not of equal width all around, the task is but partially completed and must be continued until the full streak results. On the first attempt at this rather delicate piece of work, it is well to call in an expert repair man to examine and pass upon the job.

In Fig. 10-B is shown the same process but using a brace and screwdriver bit in place of the slower screwdriver and hand. This method would hardly be advocated for an amateur attempting his first job of valve grinding, but as soon as some proficiency has been attained, it is the best, quickest, and most thorough manner.

There are, of course, a number of tools now on the market for grinding valves, some of these being constructed in such a manner as to do all the work, namely the partial turn and reverse on the grinding stroke, then the lift and partial revolution, then dropping the valve down on the seat again, and repeat. The use of one of these reduces the act of valve grinding down to a matter of knowing how to apply the emery and when and how to stop.

Noisy Valves. Sometimes the valves get very noisy and bother the driver a great deal in this way, that is to say, the wear in the valve-operating system becomes so considerable as to make a noise every time a valve is opened or closed. With the engine running at slow speeds, each one of these is heard as a separate small noise and not much is thought of it, but when the motor is speeded up, the noises all increase and become continuous and very noticeable. This may be remedied by taking up on the valve tappets which usually are made adjustable for this purpose. They should be taken up until there is but a few thousandths of an inch between the valve tappet and the lower end of the valve stem. A good way to measure this is to adjust until one thickness of tissue paper will just pass between the two; then there is approximately .003 inch between them.

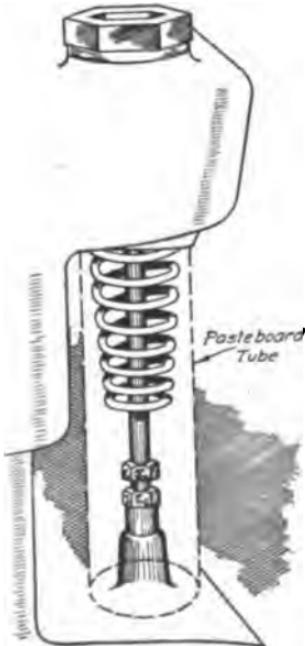
Valve Guides. When the valve guides become worn and it is not desirable to replace them, sometimes they can be remedied by adding a stuffing-box top to the offending members. This is done

by threading the outside of the valve guide, then having a stuffing box made to fit over it and screw onto these threads. In applying this, soaped string, felt, or other filling substance is placed inside the stuffing box, and when it is screwed down tightly, this will be forced up so close to the valve stem or tappet, whichever works in it, that there will be no leakage or further wear.

Valve Enclosures. On many old cars, the arrangement of the valve mechanism is such that, after several thousand miles have

been covered, the valve motions will become noisy and nothing that can be done will stop this. In that case, the best plan is to enclose each one of them in a pasteboard or other tube, and thus keep the noise in. In fact, this is a good plan even for later models. The method of doing this is indicated in Fig. 11, in which the pasteboard tube is shown in place around the valve mechanism. As this should be a tight fit between the crank case at the bottom and the cylinder at the top, the tube must be slit in order to get it on. When this has been done, however, the tube can be drawn together and fastened by means of wire, or otherwise. Besides reducing the noise, it will be found that the valve system parts will get better lubrication in this way and will pick up less dirt and dust, thus wearing less.

Fig. 11. Method of Enclosing Valve Action with Pasteboard Tube to Stop Noise and Improve Lubrication



On most all of the later models of cars the valve mechanism will be found completely enclosed. From the standpoint of cleanliness, lack of noise, and proper lubrication, this is a great improvement and obviates the necessity of such an arrangement as shown in Fig. 11. However, having the valve mechanism enclosed adds to the problem of the repair man when anything does go wrong because of the difficulties of reaching the parts. Nevertheless, the advantages of enclosed valve mechanism, particularly with the multi-cylinder types, undoubtedly greatly outweigh the disadvantages.

Valve Repair Equipment

The remarks just made in regard to enclosed valves illustrate the difference in viewpoints of the automobile designer and of the repair man. The designer must keep in mind the question of proportion of parts and the action of the particular mechanism he is designing in relation to the other parts of the machine. The interest of the repair man, however, is centered more upon how that particular part is to be reached, removed, and put back when accident or wear makes this work necessary. Often times the repair man suffers for the sins of the designer when the latter fails to consider the problem of repair in designing the part. This necessitates the design of special tools which will overcome these difficulties, particularly

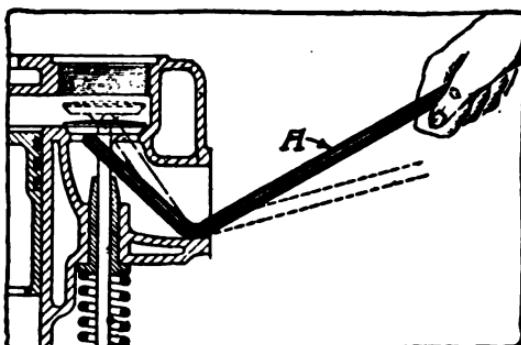


Fig. 12. Bent Tool Which Facilitates Removal of Stuck Valves

for such inaccessible parts as the valve mechanism; in such cases the interest of the repair man is particularly keen.

Curing a Noisy Tappet. Valve springs and the valves themselves, either at the seat end or at the tappet end, give the most trouble. For example, when the clearance between the end of the tappet and the end of the valve (usually from $\frac{1}{16}$ to $\frac{1}{8}$ inch) is too great, a metallic click results. Often this noise from the tappet is mistaken for a motor knock; but the skilled repair man has little trouble in finding and remedying it, for even if he cannot measure in thousandths of an inch, he knows, for instance, that the ordinary cigarette paper is about $\frac{1}{16}$ inch in thickness and from this he can estimate $\frac{1}{16}$, $\frac{1}{8}$, or $\frac{1}{4}$ inch. Ordinary thin wrapping paper is well known to be about $\frac{1}{8}$ inch; with these alone, or in combination, he can obtain $\frac{1}{16}$, $\frac{1}{8}$, $\frac{1}{4}$, and $\frac{1}{2}$ inch.

Removing Valve. Getting the valve out frequently gives much trouble, the valve often being found frozen to its seat or with the stem gummed in its guide. A tool to meet this difficulty is a plain bar or round iron about $\frac{1}{4}$ inch in diameter, Fig. 12, with one end, for a distance of perhaps 2 or $2\frac{1}{2}$ inches, bent up at an angle of about 120 degrees. To use the tool, insert the short bent end in the exhaust or the inlet opening, according to which valve is stuck, until the end touches the under side of the valve head, then lower the outer end until the bottom of the bent part or point at which the bend occurs rests against solid metal. The outer end can now be pressed down, and with the inner end acting as a lever the valve can be pressed off its seat and out very quickly.

To make this clearer, the rod, Fig. 12, is indicated at *A*, while the dotted line shows how it is pressed down and the valve forced out. The garage man can elaborate upon the tool when making it for himself by using square stock and having the inner end forked so as to bear on each side of the valve. The form pointed out above is the simplest, cheapest, and easiest to make.

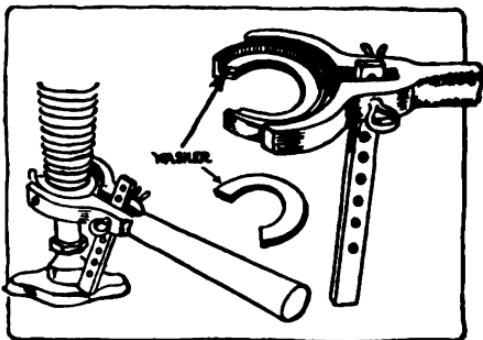


Fig. 13. Easily Made Tool for Removing Valve Spring

Removing Valve Spring. Taking out the valve spring is frequently difficult for various reasons; perhaps the springs are very stiff, or they may have rusted to the valve cups at the bottom, or the design may not allow room enough to work, etc. At any rate the removal is difficult, and a tool which will help in this and which is simple and cheap, is in demand. Many motor cylinders are cast with a slight projection or shelf opposite the valve spring positions, so that one only needs a tool that will encircle the lower end of the valve spring and rest upon this ledge, and give an outer leverage.

In working on cylinders that do not have this cast projection, a tool like that shown in Fig. 13 is useful. It consists of a yoke for encircling the lower end of valve spring and cup, with a long outer arm for prying, and a slot into which is set a drilled bar. This bar

is placed in various positions according to the kind of motor which is being worked on; when removing a valve-spring key, the lower end of the bar rests upon the crankcase upper surface, or upon the push-rod upper surface if that is extended. After slipping the grooved yoke under the spring cup, a simple pressure on the outer end raises the valve so the key can

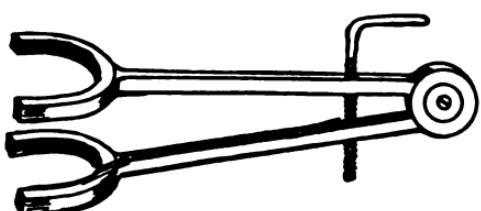


Fig. 14. Type of Valve-Spring Tool Which Leaves the Hands Free

be withdrawn. Then the removal of the tool allows the valve spring to drop down, and the valve is free.

The valve spring may be removed in two other ways by the

use of the two tools shown in Figs. 14 and 15. In the former, the idea is to compress the spring only, no other part being touched. This tool once set, will continue to hold the spring compressed, leaving the hands free—a decided advantage over the tool shown in Fig. 13. This device consists, as the illustration shows, of a pair of arms with forked inner ends and outer ends joined by a pin. A bent handled screw draws the ends together or separates them according to which way it is turned.

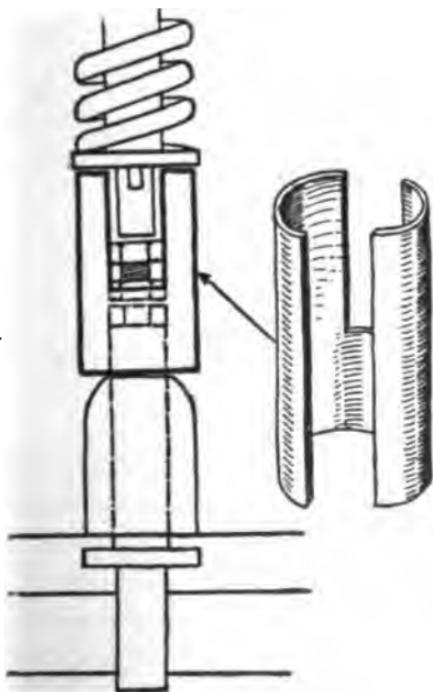


Fig. 15. A Substitute for a Valve Spring Remover Which Pushes Spring Away as Motor is Turned

when the valve is closed by turning the motor, the sheet metal piece holds the spring up in its compressed position.

Holding Valve Springs Compressed. Many times there is a need for holding the spring in its compressed form, as, for instance,

when the valve is removed with the positive certainty that it will be replaced within four or five minutes. In such a case a clamp which will hold it in compression is very useful for it saves both time and work. These may be made to the form shown in Fig. 16 in a few minutes' time, for they consist simply of a pair of sheet metal strips with the ends bent over to form a very wide U shape. A pair of these is made for each separate make of valve spring, because of the varying lengths, but as they are so easily and quickly made this is no disadvantage.

In many shops, after getting in the habit of making these clamps, the workmen take this way of replacing the spring in preference to all others. After removal of the valve, the spring may be compressed in a vise and a pair of the clamps put on. Then when the valve is ready to go back in, the spring is as easy to handle as any other part. This is especially true when replacing the spring retainer and its lock.

Stretching and Tempering Valve Springs. Many times when valve springs become weakened, they can be stretched to their former length, so that their original strength is restored. This can be done by removing them and stretching each individual coil, taking care to do it as evenly as possible. When well stretched, it is advisable to leave the coils that way for several days. This method will not, of course, restore the strength permanently; it is at best a makeshift, for in the course of a few thousand miles the springs will be as bad as before.

Sometimes weakened valve springs may be renewed by retempering, on the theory that the original temper was not good or they would not have broken down in use. The tempering is done by heating to a blood-red color and quenching in whale oil. If this is not successful, new springs are advised.

Adjusting Tension of Valves. Unless all the valves on a motor agree, it will run irregularly—that is, all the exhausts must be of

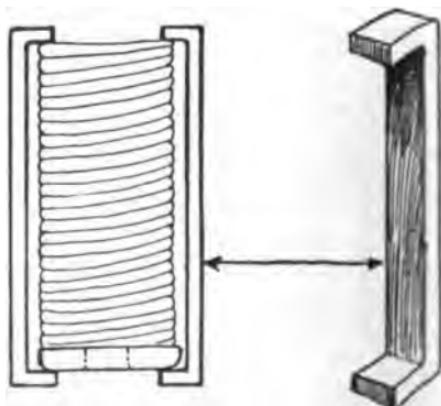


Fig. 16. Spring Clamp, Which Is Easily Made and Saves Much Work and Trouble

the same tension, and all the inlets must agree among themselves, though not necessarily with the exhausts. Many times irregular running of this kind, called "galloping", is more difficult to trace and remove than missing or other more serious troubles, and it is fully as annoying to the owner as missing would be.

To be certain of finding this trouble, the repair man should have a means of testing the strength of springs, a simple device being shown in Fig. 17. As will be seen, this consists of sheet-metal strips and connecting rods of light stock, with a hook at the top for a spring balance and a connection at the bottom to a pivoted

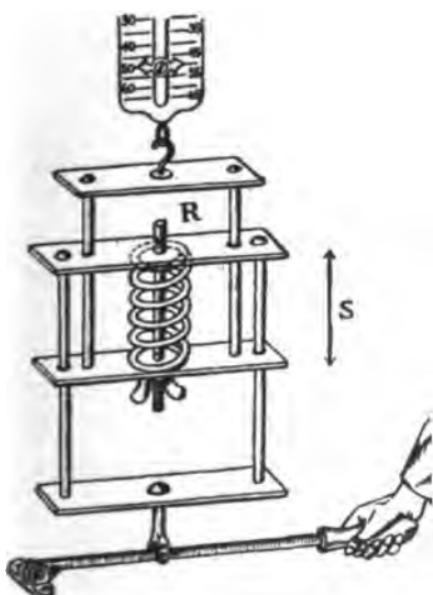


Fig. 17. Simple Rigging for Testing Valve Spring Pressure and Strength

hand lever for compressing the spring. By means of the center rod at *R* and the thumb screw at the bottom, the exact pressure required to compress the spring to a certain size may be determined. Thus, suppose the spring should compress from 4 inches to $3\frac{1}{2}$ inches under 50 pounds. By compressing it in the center portion of the device, so that the distance between the two adjacent strips of metal indicated by *S* is just $3\frac{1}{2}$ inches, the spring balance should show just 50 pounds. If it shows any less, the spring is too weak and should be discarded; if it shows any more, it is stronger

than normal—which is desirable if all the other springs on the same engine are stronger also.

If only a quick comparison of four springs is desired, the device can be made without the bottom lever, as the setting of *S* at a definite figure—say to a template of exact length—would call for a certain reading of the scale of the spring balance.

Cutting Valve Key Slots. Cutting valve key slots in valve stems is another mean job, which the repair man frequently meets. He runs across this in repairing old cars for which he has to make new valves and at other times. The best plan is to make a simple

jig which will hold, guide, and measure, doing all these things at once as all are important. Such a jig is shown in Fig. 18. It con-

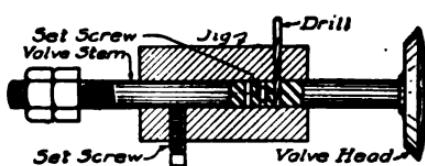


Fig. 18. A Jig for Slotting Valve Stems Which Can Be Made for a Few Cents

sists of a piece of round or other bar stock, in which a central longitudinal hole is drilled to fit the valve stem, one end being threaded for a set screw. Near the other end of the jig, three holes are drilled in from the side,

of such a diameter as to correspond with the width of key slot desired. These are so placed that the length from the top of the upper hole to the bottom of the lower gives the length of key seat desired. Opposite the three drilled holes and at right angles to them another hole is drilled and tapped for a set screw, which is used to clamp the valve rod securely and avoid any movement while the key seat holes are being drilled.

To use the device, slip the valve in place and set the bottom screw of the jig so as to bring the three drilled holes at the correct height for the location of the key seat. Then the three holes are drilled, and the valve is moved upward so that the space between the holes is opposite a guide hole, and two more holes are drilled to take out the metal between. When the five holes have been drilled, the slot can be cleaned up with a proper sized file to the dimensions required with very little trouble. This jig is so simple that it can be duplicated to any extent desired for different sizes of drill rods.

MISCELLANEOUS ENGINE PROBLEMS

Engine Noises. *Locating Noises by Stethoscope.* While the valves and valve motions previously discussed, furnish a certain amount of the rattle of an automobile engine, it should be borne in mind that there are many sources of noise in and on the engine other than these. In fact, the noises made by the valves, while an indication of loss of power, do not represent anything like the possibilities for trouble indicated by a piston slap, a crankshaft or connecting-rod pound, the whirr of worn timing gears, and others. In order to locate such sources of noise exactly, at a time when the owner lacks familiarity with the motor and its troubles, every beginner having what he considers

unnecessary noise in his engine should purchase or borrow and learn to use a stethoscope. A modification of the surgeon's well-known instrument is now made for use in automobile trouble finding.

The stethoscope, or its modification, simply magnifies all noise, its construction being such that one end is held against the suspected part while the other end constitutes an ear piece. When the engine begins to make a great deal of noise, particularly heavy pounding noises, this should be brought into play. With the motor running, place the free end against the various parts of the engine, going slowly from one to another. In this way it will soon be found where the trouble lies, and fixing it is not a difficult job.

Crankshaft Pounding. When the dull throbbing noise mentioned, is found to come from within the crankcase, possibly between two of the bearings, this indicates a crankshaft or connecting-rod pound. That is to say, either the rod is loose on the shaft or the shaft is loose in one of its bearings. Whenever the force of an explosion comes on the piston and drives it down, this looseness is taken up quickly, and the dull pounding noise is made. This is a serious trouble and if long continued may wreck the engine. That is, the loose rod may become entirely loose and free so as to thrash around and, in so doing, wreck the crankcase; or, if the pound comes from the shaft, the bearing may continue to loosen and finally that part of the shaft becomes entirely free to thrash around. Both these troubles mean tightening of the bearing caps.

A piston slap is not so easy to define or so easy to repair. It may be called a noise which comes from within the cylinders, traceable to the pistons, or to one piston, as the case may be, which sounds very much like a shaft pound, except that it is a louder noise. It occurs when pressure is put on the piston, as at the beginning of compression, at the time of explosion, and at times is heard at the end of each stroke. It is said to be due to different causes. Some say it is caused by a loose piston pin, but the writer knows of two cases in which a new tight pin left the piston slap just as clear and distinct as before. Others say it is caused by rings which are loose up and down in their grooves, but in the cases above, new rings which fitted tightly in this way, did not help any. It has been ascribed to a piston which was out of round, so that it did not fit the cylinder, and also to a groove and shoulder having been worn

in the cylinder surface, the piston striking this each time. Whatever is the real cause, and the writer is inclined to blame it to a poorly fitting piston, nothing will really remedy it but a new piston, complete with rings.

Engine Heating. *Slipping Fan.* When the engine begins to heat up more rapidly than usual, something is at fault. It may be that the fan belt has become so loose that it slips and does not drive the fan around fast enough to carry in sufficient air for proper cooling. If this is the case, tightening it will remedy the heating. This is done in various ways, depending on the engine. Many have the fan shaft set in a pair of vertical guides, in which it is clamped by means of a bolt and nut. In that case, the nut is loosened, the entire fan pulled upward until the belt is tight enough, and then the nut is tightened again. In some cases, the fan is supported on one end of a double lever arm, the other end of which has a tension spring attached to it in such a way as to maintain the tightness of the belt. When such a combination shows indication of a slack belt, it means also that the spring must be renewed or shortened.

Severed Pump Shaft. Another cause of an engine heating is a severed pump shaft in a pump-circulated system. In such a case, in theory, the water should continue to circulate thermosiphon, but as a matter of fact a pump system usually has smaller and lighter pipes, so that the circulation is not as good. Moreover, the pump itself offers considerable resistance to the flow of water through it. A shaft of this kind may shear off through weakness or a flaw, or through bits of wood or metal which get into the radiator when filling it. This simply emphasizes the fact that water should be put in with the greatest of care and should be inspected for foreign matter before using.

To repair a defect of this kind means taking out the pump. In the ordinary case, this is located between two other units, or at least there is some other unit on the rear end of the same shaft. This, however, does not give any great amount of trouble in removing the pump, but it does if this other unit is not operating because of its broken shaft. Suppose, for instance, that the other unit is the mechanical oiler. Then, the engine will not get any more fresh oil, and as soon as the supply on the cylinder walls and on the various bearings is used up, look out for trouble and lots of it. The reason

why several units on one shaft do not make much trouble in repairing is that the shaft is made with a coupling on each side of each unit. By turning it until these are in a vertical position, and with everything else disconnected, it is possible to lift the pump out bodily. This done, taking off the cover is a matter of taking out a few screws only. Then it can be seen where the shaft is broken and, if a simply constructed pump, the amateur may write for a shaft and put it in himself or can send the impeller and shaft, as removed, to the manufacturer so he can send back a perfect one to replace it.

Marking Timing Gears. Mention has been made previously of the timing gears. These are so called because their function is to

rotate the camshaft and other auxiliary shafts at the correct "time" in the cycle of events within the cylinder. They are located at the front of the motor usually, are enclosed in a tight case, and are lubricated from within by a form of splash circulation or by a lead from the mechanical oiler or otherwise. As the gears are fixed on their shafts, any movement of the

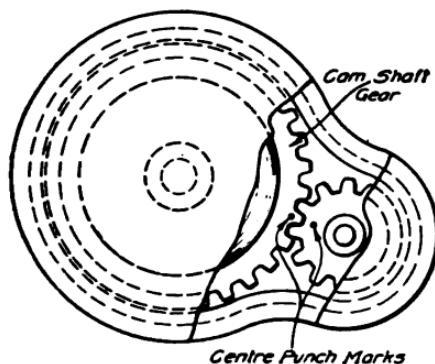


Fig. 19. Marking Timing Gears is a Simple Job and Saves Much Time and Trouble

gears, even by so much as one tooth to the next, destroys the correct relation of the two shafts. For this reason, it becomes highly important to have the gears marked so that they can be removed and put back without a particle of trouble, with no delay, and in absolute accuracy.

As shown in Fig. 19, a prick punch and a hammer are all that is needed for this. When there are but two gears, as in the case shown, it is easy to make one hole between two teeth on one gear and another which lines up with it and as close to it as possible on the other gear. Where there are three, four, or more gears, the usual practice is to make the first and third with two prick punch marks on each, made in such a way as to form a straight line when correctly assembled; and others with three punch marks on each pair at the point of meshing; and others with four punch marks, etc.

Oils. Mention having been made of oils above, it will be well to speak of these briefly. They must be purchased with much care. Once an oil is found which does the work satisfactorily, it should be adhered to consistently. No two oils are exactly alike, and for that reason, no two will do the same work under the same conditions in the same way. So, it is advisable to experiment only until an oil is found which will do the work. Thereafter, stick to that brand. As an instance of the impurities which may be found in oils, acids may be mentioned. These are fatal to delicate and closely machined parts such as ball bearings, cylinder walls, pistons, etc., and consequently they should be watched for.

Pure mineral oils contain little acid, and what they do contain is readily determined. Vegetable and animal oils, on the other hand, all have acid content and under the action of heat this may be liberated.

Testing Oil. A simple home test may be practiced as follows: Secure from a druggist a solution of sodium carbonate in an equal weight of water. Place this in a small glass bottle or vial. To test an oil, take a small quantity of the lubricant, and an equal amount of the sodium solution. Put both in another bottle, agitate thoroughly, and then allow it to stand. If any acid is present, a precipitate will settle to the bottom, the amount of the precipitation being a measure of the amount of acid present.

Another method is to allow the acid, if there is any, to attack some metal. To do this proceed as follows: Soak a piece of cloth or, preferably, wicking in the oil suspected of containing acid. Select a piece of steel at random and polish it to a bright surface. Wrap the steel in the soaked rag or wicking, and place in the sunlight but protect it from wind or weather. Allow it to stand several days, and if there is no sign of etching of the surface, repeat with a freshly soaked rag, being careful to use the same oil as before. After two trials, if no sign of the etching appears, you may take it as free from acid.

As far as the oil is concerned, it may, in its passage around through the lubricating system, gather up much dirt. While the oiling system may contain a filter, it is not wise to depend upon this alone, but the pump should be removed occasionally and cleaned. Its condition will give positive proof of the ability of the brass gauze to remove the silt. On many of the modern cars, the pump is located

at the bottom of the rear end of the crank case. In this position, it is removed by taking off a couple of bolts. The shaft, which drives it, is provided with a slip joint which allows of the removal and restoration of the pump, without dismantling the whole motor. Fig. 20 shows how a pump is removed from a crank case for cleaning. The four nuts have been taken off, after which the driver reaches in and takes hold of the pump firmly. A steady downward pull draws the driving gear out of engagement, after which the other hand is used to steady the further downward movement of the pump. This is done carefully, as the superior hardness of the gear over that of the material composing the case, renders the former liable to scratch or scrape the latter.

Other Lubricants. Although no lubricant other than oil has been mentioned, the novice driver should not think that there is no other worth using. Grease and graphite find many places of superior application on the automobile, and their use should be a matter of study. Graphite, in particular, is and has been somewhat mystifying, for it is hard to explain why it is that such a small quantity of graphite will do as much lubricating work as a vastly greater quantity of other lubricating means, such as grease or oil. This is a fact nevertheless. Graphite has found much favor of recent years as an additional substance to be put into the lubricating oil. When thus used, it renders the surface of steel rotating parts hard and glazed so that they withstand frictional retardation better. More than this, the highly polished surface which graphite imparts in a short time, allows of the use of a lessened amount of oil. These two facts account, in part, for the widespread use of graphite. It is usually mixed with



Fig. 20. Removing Oil Pump.

the oil directly in the crank case, or *splash part* of the oiling system, and should never be put into the lubricator. The reason for this is that the graphite seems to clog up not only the pipes leading to the bearings, but the moving parts of the pump as well. An excellent way to use it is to clean out the crank case and then, when putting the oil back in or putting in fresh oil, use the graphite-oil mixture. To make this, add a teaspoonful of the purest, finest graphite obtainable to a quart of oil. This sounds like a very small quantity, but it is a fact that only a very small quantity is necessary. After mixing this very thoroughly (take plenty of time to mix it, as it is time well spent) pour it into the case. In actual running the graphite will reach the main bearings, which are the places where it does the most good, as it seems to give them a sort of thin, glazed coating, which acts to protect the pins. A smaller quantity of the oil with graphite in it should be used than of the ordinary clear oil. So, too, if the lubricator or pump is of such a construction that the graphite can be put into it with safety, the feeds can be reduced to about one-half of the amount usually used. That is, the addition of graphite to the oil allows of cutting the oil consumption in half, or, at least, of reducing very materially the amount of oil used.

CARBURETER TROUBLES

Characteristic Features. Carbureter troubles form a part of the average autoist's troubles, although a very little study will show that it is a simple rather than a complicated part. Carbureters differ widely from one maker to another, in fact, from one maker's product this year to the same maker's output next year, but in the main, all work on the same principle. There is a fuel supply to a float chamber, the office of the float being to govern the level of the fuel and keep it constant. This it does through the medium of levers, weights, or other parts or combinations of parts, through its connection with the needle valve. The latter allows or prevents the inflow of the fuel, its position determining the amount flowing. From the fuel chamber, there is a connection to the vaporizing chamber, where the gasoline is sprayed into a column of air. The latter picks up the fine particles of the fuel, and vaporizes them. The resulting gas, a mixture of finely divided gasoline particles and air, is conducted into the cylinders by the suction of the pistons.

There it is ignited and burns, with resulting expansion, which moves the pistons, and thus, produces power.

If any one of the parts or operations described—the float, float controlling mechanism, needle valve, jet opening, air supply, or suction from the cylinders—be hampered, reduced, or prevented from working, the resulting mixture will vary according to the influence of the deranged or defective part or action upon the result.

Engine Should Start on the First Turn. In starting a car or any engine, whether located in a car or not, everything should be inspected so as to know if all is right before attempting a start. With the novice, this is somewhat of a task, but to the old hand it is so much of a routine task that he does it unconsciously. If all conditions are right, the carbureter is primed and the engine will start on the first turn of the crank. If it does not do so, there is a source of trouble which must be remedied first and it is useless to continue cranking. This may lie in the fuel system itself, but exterior to the vaporizer, or it may be in the ignition apparatus. It is well in a case of this sort to start with the gasoline tank and follow the fuel through each step until it apparently reaches the combustion chamber in the form of a properly proportioned mixture of gasoline and air.

To start with the tank—is there enough fuel in it not only for starting purposes, but enough to allow of making the proposed trip? This is readily ascertained by unscrewing the filler cap and inserting a measuring stick. For the purpose a graduated rule is good, but not necessary; any stick or small branch of a tree will answer, or, lacking all these, a piece of wire can be used. A string tied to a very small weight will also do if withdrawn quickly and measured at once.

Having verified the presence of fuel, the next question is: Does it reach the vaporizer as it should? Nearly all carbureters have a drain cock at the lowest point. Open this and if fuel flows out in a steady stream you may be sure that the pipe from the tank up to this point is not clogged. In case the carbureter does not have a drain cock, the same result can be effected by holding the primer down for a long time, when the gasoline will overflow through the air inlet.

In either case, if there is no sign of gasoline when the tank contains plenty, it is apparent that the feed pipe is clogged and the method of procedure is as follows: Shut off the cock below the

tank so that none of the previous liquid can escape, then drain off the carbureter and pipe into a handy pail. Next open the union below the cock in the feed line and the one at the other end of the same pipe. At both places look for obstruction. Then clean the pipe out thoroughly, using flowing water, a piece of wire, or other means which are available at the time.

Gasoline Strainer a Source of Trouble. Finding nothing here, it will be necessary to search. Look in the strainer of the carbureter to make sure that the flow is not stopped there by the accumulation of dirt and grit, filtered out of the fuel. The strainer should be cleaned often, but like many other dirty jobs is postponed from time to time.

Should this source of trouble prove "not guilty" the carbureter itself becomes an object of suspicion. Is the float jammed down

upon its seat or are there obstructions which prevent the flow of fluid? Is the float punctured, or has one of the soldered joints, if a metal one, opened, or is it fuel-soaked, if cork?

Bent Needle Valve Stem. To attend to this sort of trouble, disconnect the priming arrangement, take the cover off of the float chamber (it usually is screwed on with a right-hand thread), and take the float out. An examination of the float, Fig. 21, will disclose whether it is at fault in any of the above-men-

tioned ways, all of which are comparatively easy to fix. If the float was jammed down, perhaps by priming, the act of taking it out will cure, provided that the stem of the float is not bent and the needle valve or its seat not injured. If the seat is scored it should be ground-in just like any other valve, using oil and fine emery. A fuel-soaked cork should be thrown away if another is at hand to replace it, but if not, the cork float should be moved in its position on the stem so that it sets higher in the liquid. In other words, move the cork a sufficient amount to compensate for its loss of buoyancy.

In cases of a punctured metal float, or of loose solder, the only real remedy in either case is to resolder. It usually happens that a

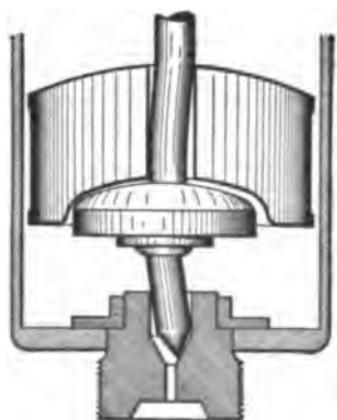


Fig. 21. Bent Needle Valve

soldering outfit is not available out on the road and some form of makeshift will be necessary to allow of reaching a place where a soldering iron may be had. If the puncture is on the bottom, it is sometimes possible to accomplish this by inverting the float so that the hole comes at the top where the gasoline seldom reaches. If the flow be reduced to make sure of this, it is possible to reach a place where a soldering iron may be procured.

A remedy which might be tried in an extreme case of this sort is to fill the float to make it heavy, so that it will have a tendency to sink. Then take a small-diameter spring, cut off a short piece of it and place it in the float chamber so that it opposes the sinking action of the now-heavy float. By carefully determining the length, and thus the strength of this spring, the same action is obtained as would be had if the float were working all right. Of course, if the entrance of the liquid fuel is such that the sinking of the heavy float tends to close rather than open the gasoline inlet, the spring would have to be on the bottom and fairly strong so as to oppose the action of gravity. But if the float works downward to open the gasoline passage, the spring will be at the bottom and very weak, simply being there to prevent an excessive flow.

Throttle Loose on Shaft. Now the carbureter trouble has been reduced to a minimum. The remaining troubles might be centered in a clogged spraying nozzle. But this nozzle is readily removed, and with it the trouble, if that be the offending member. If the spray is proven O. K., the throttle is ready for attention. If of the butterfly type, it may have become loose on its shaft, or, what is the same thing, the operating lever may be loose. In either case the shape and weight are such that it would swing into such a position as to cut off the entrance of gas to the inlet pipe and thus to the cylinder. If the throttle is of the circular sliding or piston form it may not be connected to the throttle rod, but is stuck in such a position as to prevent the passage of gas. This sometimes happens when running, and then, apparently, closing the throttle does not stop the engine. The writer had this happen to him once at a time when it was absolutely necessary to stop. The only way that trouble was averted was by the instantaneous closing off of the switch and the hasty application of the brakes.

The last hope of finding trouble in the carbureter system rests

with the inlet pipe. If the source of the trouble is not found elsewhere, take this off in search of misplaced waste or similar substances. The size of the pipe is such that anything in it large enough to cause trouble may be instantly seen and removed. The only exception to this is a small hole in the inlet pipe casting, which will not only cause trouble with the mixture at all times, but is also very hard to find, particularly if it happens to be of very small diameter, caused by a single grain of sand, for instance.

The valve or cock controlling the flow of liquid from the tank should be examined frequently and care be taken to keep it in good shape. It must act hard and must be tight, so that no gasoline flows when it is supposed to be shut off. The reason for having it act hard is to prevent it jiggling shut during a long run, which results in the engine slowing down and stopping without any apparent reason until the tank is looked at, when the supply is found to be shut off. A method of fixing it—which, in general, is not to be recommended—is to open the cock and then hammer the handle so as to jam it tight against the seat, but in the open position. This makeshift will answer until a place is reached where the taper seat can be reground or tightened in place, if that is what it needs. In case the driver does not wish to do this, and the cock is of the two-way type—open when the handle is parallel to the axis of the pipe—it may be tied in the open position by passing a cord around the cock and pipe.

Carbureter Adjustment. In adjusting the carbureter the worker should remember that the correct proportion varies from 11 to 14 parts of air to 1 of gasoline vapor. It is not always possible to measure the two in just this way, but the adjustment is provided for in the carbureter. The tendency in carbureter construction is toward simplification and fewer adjustments.

Rayfield Gasoline Adjustments. In the Rayfield, for instance, the auxiliary air is automatic and cannot be adjusted, but there are two gasoline adjustments. In both of them the arrangement is such that the screw heads are turned to the right to give a richer mixture. The first adjustment, for low speed, is as follows: With the throttle closed and the dash control lever down, close the nozzle needle by turning to the left until the small block slightly leaves the cam; then, turn to the right about three complete turns; open the throttle not more than one-quarter. This is the preliminary adjust-

ment. Start the motor, and after it has warmed up and is running well, throttle down to the lowest possible speed. Turn the low-speed screw to the left slowly but steadily until the motor slows to a marked extent and shows signs of stopping. Turn back to the right a couple of notches, and if the motor steadies down and idles smoothly, lock it in that position.

The high-speed adjustment is made as follows: Advance the spark about one-quarter, then pull the throttle open quickly. Should the motor backfire, that indicates a lean mixture, which is corrected by turning the high-speed adjusting screw to the right, one notch at a time, until the throttle can be opened quickly to the full extent without back-firing. If choking or loading occurs when the throttle is opened wide, turn the screw back to the left a notch or so. Lock this adjustment when it has been made.

In making carbureter adjustments, always remember to make them with the motor hot. A good plan is not to make any adjustments of this kind until after the motor has been running for an hour.

Tool for Carbureter Nozzles. Many carbureter nozzles are made with a screw driver slot to facilitate their removal. It will soon be found, however, that the screw driver is not so easy to use on these as a home-made tool. One useful form consists of a bar of $\frac{1}{4}$ -inch steel bar stock bent into the form of an L, the short end being flattened down into a screw driver thickness and hardened.

Carbureter Nozzle Too Low. A rather common trouble is failure to start readily. One puzzled driver described his case as follows:

The engine starts hard, necessitates priming, and the primer must be held down for a long time. When this is done, it will start and run for a short distance, when it will stop and the same proceeding must be repeated. On taking the carbureter apart, everything was clean and apparently all right.

If you are ever bothered in this way, you may be sure, granting that the spark is good, that the trouble lies in the fuel system. From the description of the trouble, it appears as if conditions were such as to starve the engine, although this was doubtless done unconsciously. This action is due to the fact that the gasoline level has been lowered so far that the suction of the engine does not draw up sufficient fuel for running. The fact that you have to prime to start and then prime to keep a going, even this priming failing to work sometimes, would seem to prove that the engine is not getting enough fuel. The

trouble is that the spray nozzle has been raised too high, so that the gasoline level is four or five times as far below the nozzle as it should be. The engine suction must raise the gasoline this distance before any of the fuel will get into the cylinder, and if the distance exceeds the height to which the suction can raise the fuel, none will pass over. In a case of this sort, priming only helps temporarily.

Carbureter or Magneto. Another similar trouble, with a similar remedy is that of the engine ceasing to do its best work or "laying down" under a heavy load such as a stiff hill, deep sand, wet, sticky mud, or similar circumstances in which the maximum power is required. A driver bothered in this way described his trouble thus:

Whenever I get in a heavy pull and open the throttle wide, the engine back-fires in the carbureter. It never does this on smooth road or when running under ordinary conditions, no matter how much I open the throttle. The trouble seemed to be worse on the magneto than on the batteries. New spark plugs and new batteries helped very little, nor did cleaning the carbureter.

This is apparently carbureter trouble, but the thorough cleaning and adjusting done there would seem to indicate that it is not at fault after all. About the only other solution is that the magneto is slightly out of time, say, to the extent of one tooth, on the driving gear. As the result of this, on slow speeds and even at high speeds with but little load, the effect is not bad enough to be noticed. When working under a heavy load, however, even a slight error in the timing is greatly magnified. The same results might be caused by the valves being incorrectly timed, possibly, by the same small amount, *i. e.*, one tooth out of the way in the meshing of the driving gears. In case making the changes indicated above does not remedy the trouble, look at your inlet valve springs, or at anything else that could possibly cause the inlet to close late or slowly. Look at the valve seats to see if they are in good shape.

Wrong Adjustment of Jet Nozzle. The wrong location of the jet nozzle results in the fuel level as fixed by the float not giving the proper flow of fuel into the vaporizing chamber. Drivers who have trouble with this are frequently puzzled by it, because they assume that the carbureter is properly adjusted before leaving the factory. This is not always the case. One young driver said:

What is the cause of this very puzzling knock? My four-cylinder engine develops a bad knock on a hill, which can only be eliminated by retarding the

spark, but when that is done, the engine "dies," that is, gives no power. The effect is the same on level roads, when the throttle is opened more than one third. I may have deranged the level of the gasoline within the carbureter, while cleaning it. Would that have this result?

Now, this trouble is directly traceable to the change in the level of the nozzle made when cleaning, and made unconsciously. To quote from a plain statement of the effect of this change:

By raising the spray nozzle, you lower the level of the gasoline relatively. Therefore, the liquid is less sensitive to the suction, which would reduce the amount of gasoline used. At low speeds, there would be a tendency to *starve* the engine which would be most noticeable on hills.

The trouble is, that the spray nozzle has been raised so that the engine does not get enough fuel at slow speeds and on hills.

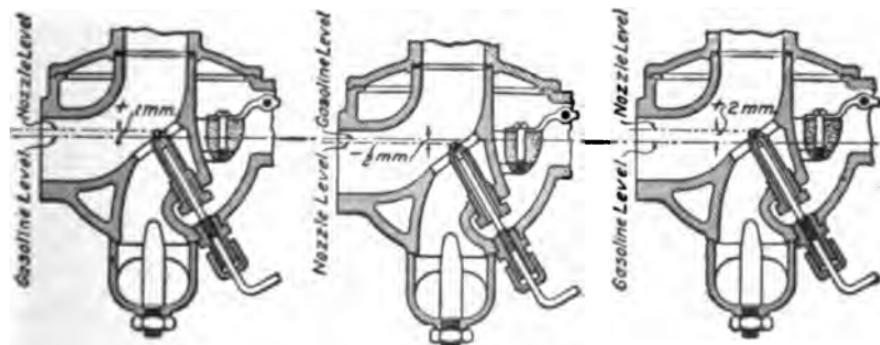


Fig. 22. Section of Carburetor Showing Variations of Nozzle Level. First Figure, Correct. Second, Too Low—Engine Will Flood; Third, Too High—Engine Will Starve

By lowering this a small amount, Fig. 22, the engine will be able to suck up more fuel and the trouble ceases with the change. In making this change, be careful not to lower the nozzle too much at once, as the effect then is just as bad, the carburetor flooding at the slightest provocation. The better way is to lower the nozzle a very slight amount, say one-quarter of a millimeter, or perhaps one sixty-fourth inch would not be too much. Try this level out very thoroughly, and when you are satisfied that it is not right, alter the level once more. The experience that you will get during the process of finding the right level will be worth all the time taken up in the series of successive adjustments.

Starving at High Speeds. Many times a motorist will experience the phenomenon known as starving at high speeds—that is, his

motor will give better power and run faster with the throttle partly closed than when wide open. This peculiar condition is caused by the auxiliary air valve not opening sufficiently to admit the large quantity of air needed at the widest throttle opening, which results therefore, in the mixture becoming too rich and causing the motor to starve.

This trouble points out the fact that auxiliary air-valve adjustment was not covered in adjusting the carbureter just described and this was because the Rayfield does not have an auxiliary air-valve adjustment. This valve usually has an outside spring, the tension of which is controlled by a milled nut, also on the outside. Then, when it is desired to make a change in the mixture, the nut is turned, altering the tension of the spring, and thus, altering the lift of the air valve; in this way the proper amount of air is admitted. To admit more air, the nut is backed off in order to weaken the tension and thus allow the air valve to open wider. To admit less air, the spring tension must be increased so that the air valve cannot open quite so far, or stay open so long.

Adjustments for Heating Water and Air Supply. On a large number of carbureters there are two more adjustments—the heating of the water and the heating of the air. The general run of carbureters now are water-jacketed to help vaporize the heavy fuels, and during warm weather this may supply too much heat. For this reason, a cock is generally fitted to the hot-water line which will allow partial as well as total closure.

Similarly, hot air is supplied to almost all carbureters to vaporize the heavy fuels more quickly, a necessity if rapid acceleration, quick getaways, and other present-day demands are satisfied. In order to vary the hot air according to the weather or to cut it off entirely, some kind of a shutter is provided which can be locked in any position. When the days begin to grow warm late in the spring, the shutter is partly closed; during the heat of mid-summer, it is closed completely, and sometimes the connection with the exhaust manifold for heating the air is entirely removed from the car; when the temperatures begin to go down in the fall, the shutter is partly opened again, and in cold weather it is entirely open and as much heat as possible is supplied the carbureter so as to give the required vaporization.

Smallest Detail Important. The influence of the smallest things may be of great importance, as illustrated in Fig. 23. A man having a small runabout with a rather large air vent in the gasoline tank, which latter was located directly over the engine, was bothered, in climbing hills, by too rich mixtures. These not only caused the engine to smoke badly, but caused a lack of power. On investigation, he found that the carbureter was located below and nearly underneath the gasoline tank. On a hill, the gasoline flowed out of the air vent, down the side of the tank, and dropped into the air intake thus increasing the mixture. Obviously the cure for this was to change the air intake so that the overflow from the tank could not drop into it, or any part of the carbureter. The sketch, Fig. 23, shows how he was advised to change it; the comment on the trouble and the proposed change were as follows:

The addition of fuel, as you describe, to the air at the air inlet will seriously disturb the running of the engine and probably give so rich a mixture as to choke the engine. It is advisable to remedy this at once, and the best way to do this is to prolong the present air inlet upwards and outwards away from the gasoline tank which causes the

trouble. To do this, have a sort of stove pipe made of galvanized iron, tin, or any similar metal. It should be long enough so that its top is as high as the top of the offending tank, then make a big, easy bend away from the latter. The opening or mouth of the pipe should be so formed as to take a screen, which is necessary to keep out the dust, and should preferably be made removable, so

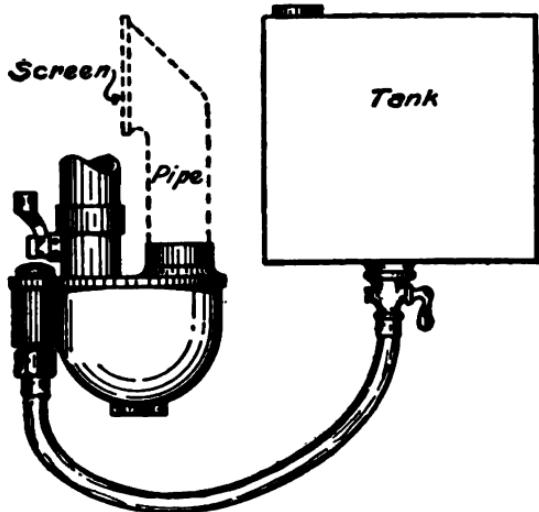


Fig. 23. Puzzling Carburetor Problem Solved.

that when the screen clogs with dust it can be taken off, cleaned, and replaced. For this purpose use a very fine brass gauze, which can be obtained at any hardware store, and for a small cost.

IGNITION TROUBLES

There are a number of vexatious things to make the novice and prospective driver peevish. Chief among these is the trouble known as *misfiring*. This may be described as a failure of the mixture to fire in any one cylinder. It is usually due to ignition, so that the term as used, now means a failure to fire a charge due to an electrical cause. However, there are many common misfires which are due equally as much to a failure in the fuel supply system, so that the latter meaning attached to the word is somewhat of a misnomer.

Among the causes which contribute to misfiring may be mentioned ignition troubles, such as short circuit in wires, exhausted battery, pitted or improperly adjusted vibrators of the coil, sooty or cracked plugs, loose connections or switch, dirty timer or commutator, punctured condenser, moisture in coil, wet wires or cables, water on distributing plate, dirt or wear on contacts in distributor, or dirt or wear in timer.

Then, there are the misfires due in part or wholly to the fuel or carburetion system. These may be grouped or listed as follows:

Carburetion and Fuel. Faulty mixture, sediment or water in the carbureter, clogged gasoline strainer, leaky float, clogged spraying nozzle, bent float-valve spindle, stale gasoline, partial stoppage of fuel supply pipe, hole or obstruction in intake pipe or manifold—these are not all the things that might happen, but are the principal ones which the writer's experience has suggested as most likely to occur to cars in general.

Foremost among the several difficulties which may be called *common* misfires, is the lack of a proper mixture. A rich mixture containing a relatively large proportion of gasoline in proportion to air is never desirable, inasmuch as it deposits considerable soot upon the piston, cylinder walls, and valves, and is, moreover, a waste of fuel. The motor will seldom run well on a very rich mixture, and the carbureter should be so adjusted that no more gasoline is fed to the mixing chamber than is sufficient for the motor to develop its full power. The exact mixture may be found by experiment.

A very rich mixture will cause misfiring; the motor will have a tendency to choke at other than high speeds, and is likely to overheat.

A lean or too thin mixture will, on the other hand, lower the efficiency of the motor, giving it a marked tendency to miss at high speeds, accompanied by a popping sound in the carbureter. In this case the needle valve should be adjusted to admit more gasoline, or if due to an excessive supply of air, the auxiliary air-valve should be adjusted to admit less air.

Bent Float Spindle. A bent float spindle will cause missing in one or more cylinders. The float spindle may become bent or it may become jammed into its seat by too vigorous priming. This may be discovered by unscrewing the cover and lifting out the float. Considerable care should be taken in straightening out a bent spindle, and the metal should be placed upon a block of hardwood, another block interposed, and the spindle gently tapped with a hammer.

Leaky Float. A leaking metal float or a fuel-logged cork will cause missing owing to its uncertain and erratic action. A cork float should be thoroughly dried out and then given a couple of coats of shellac to prevent it from absorbing the gasoline. As a new float is not at all expensive, the driver will probably find it more convenient to put in a new one. A metal float must be soldered when it leaks, and as the copper is thin and easily damaged, only a very little solder need be used. Precaution should be taken to keep the hot soldering bit away from the metal.

A clogged gasoline strainer is often the cause of trouble, and this is about the first thing that the autoist should examine when the misfiring is apparently in the fuel supply system. The brass gauze strainer should be frequently taken out and cleaned of any dirt that may have been filtered out of the gasoline.

Obstructed Spraying Nozzle. Owing to the small needle-like opening in the spraying jet, it is not uncommon for a particle of grit to lodge in the orifice and partially stop the flow of gasoline. The obstruction will not always interfere with starting, but as soon as the motor speeds up, the amount of gasoline sucked through the nozzle will not be sufficient for the motor at higher speeds, and it will soon begin to misfire until the motor slows down to first speed. A leak in the intake manifold will cause misfiring in one or two cylinders, and is often mistaken for ignition trouble. The cause may be due to loosening up of the bolts securing the flange to the cylinder.

Inlet Valve. The inlet valve is often the seat of the trouble, and missing here is generally caused by a weak or broken spring, a bent stem, or a carbonized valve. If the valve spring has lost its temper and broken down, the tension will be insufficient to properly hold the valve on its seat and the gas will partially escape and so cause missing. The insertion of an iron washer or two will increase the tension of the defective spring and serve as a temporary road repair. A broken spring may be similarly repaired by placing a washer between the broken ends. A bent valve stem should be taken out and carefully straightened by laying it upon a billet of wood with another block interposed between it and the hammer. Only a very little force is needed, and the stem should be repeatedly tried until it slides freely in its guide.

As was stated before, however, electrical troubles cause the greater part of misfires, and a simple explanation of the more common troubles of this kind will be of much service.

Troublesome Short Circuits. Either a partial or a considerable leakage of the electrical current may be due to worn or frayed insulation, and the bare wire may possibly come in contact with some metal part, and so form a short circuit to the ground. This may or may not prove a constant short circuit, as it sometimes happens that the vibration of the car will cause the bare wire to shift about, and the "short" will occur only now and then, as the wire brushes against the metal at intervals. Trouble of this kind is generally due to poor and old-time connections, and will but seldom occur with modern terminals. Perhaps the easiest and best way of correcting this trouble is to wrap a little tape around both the ends of the damaged cable and its binding post, which will keep the loose ends together and at the same time make certain of a good contact at the post.

Failures of the spark plugs due to defects in material and manufacture are not so common nowadays as in the past, but modern plugs are by no means immune from trouble. It is well to test the plugs if trouble is suspected. To do this it should be first ascertained which of the cylinders is misfiring by holding down all the vibrators of the coil but the one to be tested. This is inconvenient without assistance, but the vibrators may be cut out of action by simply inserting a bit of stout paper between the platinum contacts. When the missing cylinder is found, unscrew and examine its plug.

and if the points are clean and everything looks all right, connect up the high-tension wire, lay the plug on the cylinder, and turn the motor over until the proper contact is made. In case no spark is forthcoming and the plug is clean and to all appearances in good condition, it is very probable that the porcelain has developed a crack sufficient to form a leak and cause a troublesome and elusive "short."

However, this method of testing a plug is not infallible, since a minute crack in the insulation—not always visible to the eye—may not interfere with the production of a good spark in the air, but will cause leakage and so make a weak spark, or none at all, when called upon to overcome the greater resistance of the compressed gas. The electric current will always follow the path of least resistance, and as it is called upon to overcome considerable resistance in jumping between the two electrodes of the plug, it is obvious that a comparatively small defect in the insulation will prevent the production of a fat spark at the points.

Broken and Wet Wires. Broken and wet wires are occasionally the source of misfiring, and although little trouble may be anticipated from the well-made modern cables, the wiring of older cars—so largely seen in second-hand shops—is frequently defective. Where the wiring bears unmistakable evidence of having seen better days, the only satisfactory remedy is to put in new wiring throughout the car.

Wet wires are likewise the cause of considerable trouble in the older cars, as in many instances the high-tension cables are carried underneath the flooring and, being unprotected, are likely to get short-circuited through the water and mud splashed up by the wheels. In cases of this kind, it is desirable to re-wire the entire system when possible. In some cars, where this is not convenient, an old length of rubber hose may be pressed into service to enclose and partly protect the otherwise completely exposed wires.

Frequently, it is thought necessary to remove the magneto for examination or adjustment. This was formerly considered quite a task, but with the modern method of mounting, it is very readily effected. As Fig. 24 shows, most magnetos are now strap-held. To remove, then, it is only necessary to loosen the bolt or nut which holds the end of the strap, lift the latter off, and remove the magneto. This assumes that the various wire leads to the switch, cylinders, etc.,

Exhausted Battery. A rundown battery is a very common source of misfiring, and although the symptoms are plainly apparent troubles of this kind, the difficulty is not always traced to the proper use. The fact that a weak battery will not generally prevent starting and only causes a misfire after the car is well under way, is, no doubt, the reason why the real trouble is not at once suspected. And again, the motor may run fairly well at medium speeds, but when the throttle is opened to admit more gas, the spark is too weak to fire the heavier charge and the motor commences to misfire, finally coming to a stop. In fact, when the battery fails to respond to the spark advance lever it may be taken as pretty good evidence that the voltage is too low, and that a new set of dry cells should be connected up, or the battery re-charged if of the accumulator type.

If the two sets of dry cells are used, they may be made to give some little additional service by connecting up in series—carbon to zinc. If two storage cells furnish the ignition current, connect them up in parallel—carbon to carbon and zinc to zinc. To avoid the annoyance of a weak battery, each dry cell should be occasionally tested for amperage and the defective cell renewed. A storage cell should be charged regularly once a month, and should never be allowed to become discharged.

Switches occasionally work loose, and, while an uncommon source of misfiring, it will occur now and then. A loose switch generally provides such poor contact that the motor will stop completely, but it may also cause missing in but one or two of the four cylinders.

The timer or commutator should be washed out thoroughly with gasoline at least once a week, to remove dust or other substances which will likely interfere with a perfect contact. If neglected, and dust and oil allowed to accumulate, the contacts will be imperfectly made and, the current being poorly distributed, misfiring will ensue.

Condenser and Short Circuit in Coil. The condenser is not likely to cause trouble, and the most serious injury likely to befall this important part of the system is a puncture caused by the use of a battery generating a higher pressure (voltage) than the coil will stand. In this case the coil must be sent to the makers for repair. It occasionally happens, however, that misfiring results

from a broken connection to the condenser, or is due to the presence of dust or oil on the spring contacts. If trouble is suspected in the condenser, the contacts should be examined and cleaned with a bit of cloth wet with gasoline.

Water or Moisture in the Coil. Water or moisture in the coil will form a short circuit and produce missing in the cylinder, and will rapidly exhaust the battery current. A primary or single wound coil—such as is used in low-tension make-and-break ignition—may be dried out, but the only way to fix up the high-tension coil is to send it to the manufacturers.

Spark Plugs. Plugs, whether of mica or of porcelain, give trouble if they break, if they are poorly set in the cylinders, if they

become badly carbonized, if short-circuited by water, etc. Sometimes a plug will break off on the road. When this happens and the driver has no other, he can disconnect the wire leading to that member, and limp home with but three cylinders firing. One motorist managed this with a broken plug, which fell apart when touched with the wrench, leaving a hole in the cylinder. He had no extra plug, and nothing to fit the hole, which left open would allow gas to escape. As shown in Fig. 25, he overcame this by finding out that a dime just fitted the interior of the plug. Then he drove this in, as

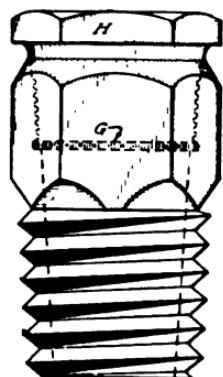


Fig. 25. How a Motorist Plugged a Broken Spark Plug with a Dime

shown at *G*, screwed the plug shell back in place, and got home all right.

If the plugs are set up too high, a large pocket is formed beneath them and this fills with dead gas. This always slows the progress of the spark to the combustible gases below and sometimes obstructs it so that the gases are not fired; in short, the cylinder "misses" fire. And just the opposite of this often happens—the plug may be set down into the cylinder too far, in which case its lower end is exposed to burning gases and the force of each explosion.

Some of these troubles are pointed out in Fig. 26, which shows at *A* a plug set up too high, with a pocket of dead gas below it; at *B* a correctly located plug; and at *C*, one which is set down into the cylinder too far. This latter situation can be remedied by taking

out the cap in which the plug is located, removing the plug, and having the cap bored out at the top, and re-threaded at the bottom, as shown at *D*. Then, when the cap is replaced, a different form of plug—a shorter and larger type—is used so as to bring it down to its correct position.

Magneto. In addition to those misfiring troubles which have just been mentioned, many of which are common to both magneto and battery systems, there are a few misfiring troubles which are confined to the magneto itself. Perhaps one of the most common causes of magneto misfiring is due to the interrupter-contact-arm roller becoming worn. A fiber roller will often wear unevenly, causing the cam to slip over the worn flat spot without making a good contact. In case of steel rollers and fiber cams, the latter will sooner or later show signs of wear.

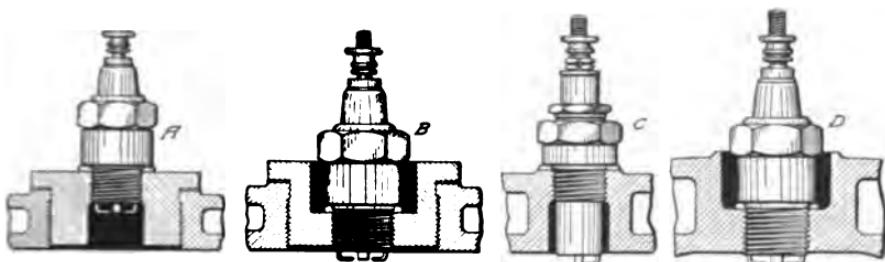


Fig. 26. Various Proper and Improper Spark Plug Locations—*A*, Too High; *B*, Correct; *C*, Gas Chamber Wrong; *D*, Correction for *C*

Wiring. Much of the motor trouble comes from the wiring and one sure way to avoid a large part of the trouble is to take the wiring up out of the way of the worker's hands and away from oil, water, or dirt, and at the same time eliminate the possibility of wear caused by the rubbing of the swaying wires.

Primary wires fitted to the timer or commutator do not as a rule receive a great deal of attention, because they carry a low-voltage current. Consequently, the general idea is that leakage is at a minimum, or else that it does not matter anyhow. Such is not the case; primary leads should have almost as good attention as the secondary. In the case of a timer, where the wires lead up vertically, the four wires are generally allowed to sag down any old way. This can be remedied very simply, cheaply, and, at the same time, the appearance improved by cutting from a piece of fiber or

similar material, a round disk, as shown at the right of Fig. 27. Then a fairly large hole is cut through the center of it and four small holes, equally spaced, just the size to take the wires without trouble.

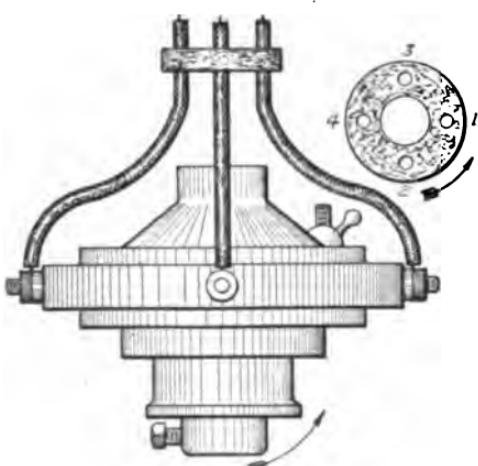


Fig. 27. A Method of Gathering and Holding Timer Wires to Preserve Them

closely together, in a neat workmanlike manner, at the same time supporting the ring. This will not chafe or cut them, either.

Wiring Conduits. The greater part of the wiring now is placed in a form of metal or fiber conduit, which protects and preserves

them. Some makers have gone so far as to have wires imbedded in the fiber so that connections on the sides were the only places where short circuits or other trouble could occur. This, however, is an expensive plan, and the general scheme is to use a long metal or fiber tube, suitable holes being cut opposite the various spark plugs while the

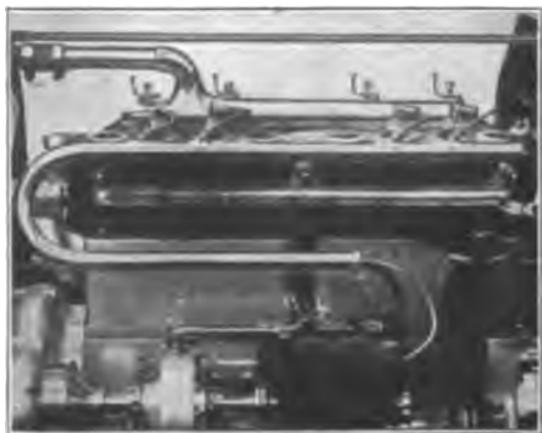


Fig. 28. Method of Housing Wires in Brass Conduit, as Used on Rochet-Schneider (French) Car

end into which the whole bunch of wires enters is perfectly plain. To illustrate: Fig. 28 shows the wiring conduit of metal

as used on the Rochet-Schneider (French) 25-horsepower four-cylinder car. Note how this is bent down so that the lower end is just the right distance from the terminals on the magneto, while the upper part runs along the edge of the cylinders just a short distance from the plugs. Opposite each one of these there is a small hole, fitted with a fiber ring to prevent chafing, through which a wire emerges and runs to the plug. The pipe is held in place by a pair of thin clips, soldered to it, and bolted with the same bolts as hold the front and the rear ends of the exhaust manifold. An arrangement of this kind reduces trouble to a minimum. When repairs are to be made, the ends are disconnected, and by loosening two nuts, the entire pipe and wiring is lifted out of the way.

If a car is not equipped with anything of this kind, the handy amateur can readily make a tube of the straight kind into a conduit, by cutting it to the right length, cutting in the holes opposite the spark plugs, and arranging a clamping means for both ends. The tube can be obtained at any repair shop at small cost.

Miscellaneous Troubles. The contact interrupter spring is also a common source of missing, as the spring loses its elasticity and becomes weak through constant use. Loose interrupter contacts are not quite so common, but will occasionally cause misfiring by working loose and so provide insufficient surface to insure a good contact.

Armature bearings work loose in course of time and cause misfiring by making too short a contact. Dust on the insulated face of the distributor is likewise conducive to missing, and the autoist should make it a point to keep this surface clean.

MEASURING INSTRUMENTS

A point worth more than passing mention is that all ignition troubles may be detected at once by the use of common electrical measuring instruments. The two ordinary instruments are the *voltmeter* and the *ammeter*. The former measures the voltage or the pressure of the current, while the latter indicates the rate of flow or amperage of the current. Since both are necessary, they are combined in the modern instrument into a single unit, Fig. 29. When

mounted upon the dashboard of the car, it is connected up as shown in the wiring diagram, Fig. 30. With this instrument in position and connected up, one may make a simple test at the slightest sign of trouble, and find out at once the source. Moreover, aside from making a test of this sort at will, it is possible to tabulate the common electrical troubles, their indications on the instruments, and their remedies. This makes a glance at the instruments, and another at the table, sufficient to start a person on the process correcting the trouble.

How to Proceed with the Test. In proceeding to make tests with the volt-ammeter, after having connected it up as indicated, the first thing to do is to make the distance between the spark-plug points as nearly uniform as possible, so that the width of the gap shall not exceed $\frac{1}{16}$ inch and then file the platinum points of the vibrators and contact screws so as to be sure that they are perfectly flat and true as well as smooth.

For this operation, a Nicholson XF Swiss file, about number 6 cut, should be used, because the ordinary fine-cut file is too coarse

and cuts away too much metal. After filing the points, the contact screws of each unit should be screwed down until the vibrator has a play of about $\frac{1}{16}$ of an inch between the screw and the iron core.

Then, with the gasoline supply to the carbureter shut off and

compression relief cocks open, turn the engine over until the timer makes contact and sparking takes place in one of the cylinders, any one being equally good.

Note the reading of the ammeter when the timer closes the primary circuit, and if the current consumption of the coil is greater than $\frac{8}{16}$ ampere, increase the vibrator gap by unscrewing the contact screw, and thus decrease the flow of current. Should the vibrator fail to act, however, screw down the contact screw and thus decrease the gap until the vibrator is brought into action. Proceed in the



Fig. 29. Hoyt Volt-Ammeter.

same manner to adjust each of the vibrators until the current consumption of the coil units is equal throughout their number.

In making adjustments while the engine is at rest, the circuit being closed by the timer for a considerably longer interval of time than when in actual operation, it is necessary to set them for a current consumption about twice as great as is desired, because in actual operation the flow of current through the coils is intermittent, and the ammeter needle will stand at a point representing the mean current flow. For example, a two-unit coil adjusted to take $\frac{1}{2}$ ampere would show from $\frac{1}{3}$ to $\frac{1}{2}$ ampere on the ammeter, depending on whether the period of make or period of break is the longer.

Effect of Construction on Consumption. Since the construction of a coil affects the current consumption, and wide variations in the sparking efficiency of different

makes arise from differences in usage as well as construction, no definite rules can be given for the exact point at which a coil vibrator should give best results. Generally speaking, however, it may be said that a coil adjusted to operate on less than $\frac{1}{10}$ ampere will give a thin, weak spark which would only fire a rich mixture. When adjusted to take more than $\frac{8}{10}$ ampere, trouble will be experienced from pitting and sticking of the platinum contact points and from rapid deterioration of the battery.

With the volt-ammeter in circuit, an observation of the normal rate of deterioration, after adjustments have been made, enables the operator to ascertain the relation between mileage and battery consumption. For instance, if a car will run 300 miles when the current consumption is such as to cause a pressure loss of $\frac{1}{2}$ volt, then the car

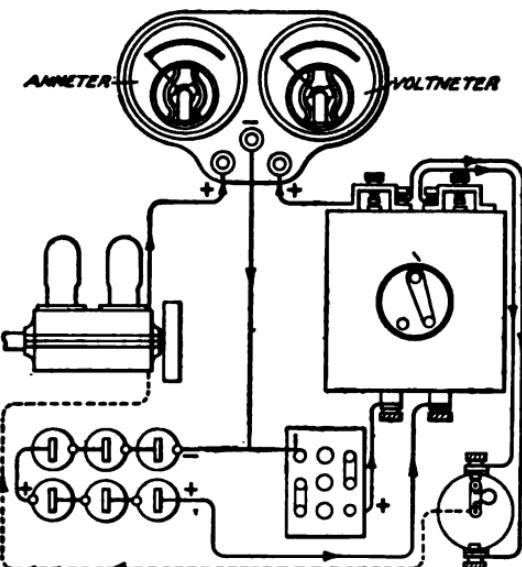


Fig. 30. Wiring Diagram for Volt-Ammeter Circuit.

TABLE I
Common Ignition Troubles and Remedies

READING OF VOLTMETER	CORRESPONDING AMMETER READING	CAUSE	REMEDY
Steady. . . .	Regular	Normal Conditions.	None Necessary
Oscillating needle	Irregular	Loose contact in battery circuit—Leakage of secondary current — Short circuit or exhausted cells	Tighten connections—See that timer contact is made evenly—Eliminate leakage
Uniform or gradual drop	Regular	Normal deterioration of battery	None required
Abnormal drop	High. . .	Rapid deterioration of battery because of short circuit at plug or in battery box—Improper adjustment of coil-vibrator or spark plug gaps, latter being too narrow—One or two exhausted cells	Eliminate short circuit—Readjust vibrator and spark gaps—Replace exhausted cells
Normal . . .	Low. . .	Poor contact in timer, vibrator, or connections—Short circuiting of cells	Clean contacts, eliminating effects of corrosion or wear
Normal . . .	High . . .	Sooted spark plug—Gaps at vibrator or spark plug too small—Decreased coil efficiency	Clean spark plugs—Increase width of gaps—Readjust tension of vibrator spring
Normal . . .	Irregular	Poor timer contact.	Fix timer
Normal . . .	Zero . . .	Broken ground wire.	Put in new wire
Zero	Zero . . .	Broken wire between coil and battery or broken battery connections	Put in new wire

will run another 300 miles with a like drop in voltage, whether the battery is of the primary dry-cell or of the secondary storage type. Hence, a glance at the voltmeter will enable the operator to judge what mileage can be obtained from the battery before it is exhausted.

Whatever may be the cause of a change that affects the battery circuit, the voltmeter gives instantaneous indication thereof, the needle or pointer remaining steady only so long as conditions are normal. With a loose contact, the needle would oscillate back and forth; with a broken wire it would not move from zero; with a poor contact due to a corroded terminal, the reading would be lower than normal.

What the Ammeter Reading Signifies. The operator having also familiarized himself with the significance of the ammeter indications, a glance at it shows whether there is a normal flow of current through the coil. Any departure from normal conditions, in fact, any change in the circuit that causes a variation in the quantity or volume of current flowing through the coil is shown and can be accounted for by the behavior of the ammeter, whose indications serve as a reliable guide in locating ignition troubles. Poor contact is shown in a diminished current flow; too small a gap between the vibrator or spark points is indicated by an abnormally high reading; and a short circuit at the spark plug, due to soot or breakage, will throw the needle to the extreme point. A loose connection causes oscillation. A study of Table I will give some idea of the extent to which the voltmeter can be of service in detecting ignition troubles.



Fig. 31. Hoyt Pocket-Size Volt-Ammeter

Courtesy of Hoyt Electrical Instrument Company, Penacook, New Hampshire

Testing, Adjusting, and Maintenance of Ignition System. Automobile users as a rule know less about the ignition systems than about almost any other part of a car. This fact, together with the fact that ignition systems are subject to obscure ailments which are difficult to diagnose, tends to make ignition troubles numerous and serious.

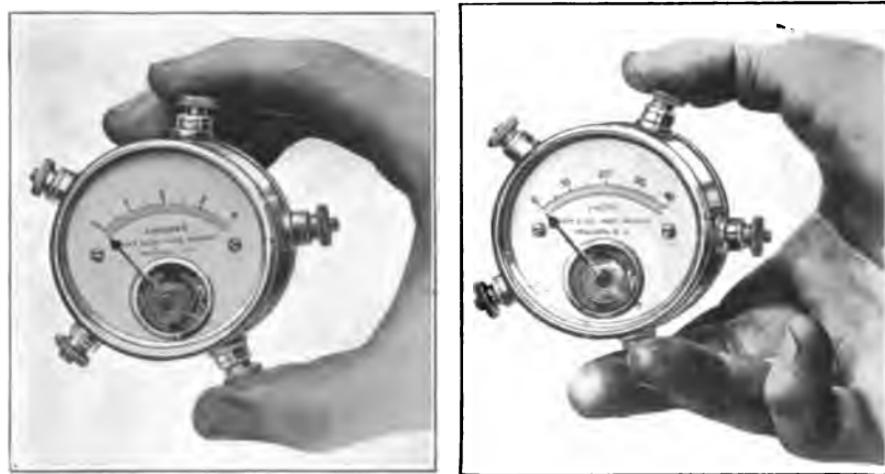
Nevertheless, with the knowledge of a few rudimentary facts, and consistent observation of a few simple rules, ignition trouble can be reduced.

Use of Volt-Ammeter. It always is necessary to see that the current supply is of the necessary voltage, particularly if batteries are used. With batteries, a voltmeter should always be kept handy, to test the voltage of the cells. This is more important with storage cells than with dry cells, and for the latter a good ammeter is perhaps more practical than a voltmeter in unskilled hands.

It is apparent from this that there is a need on the part of every car owner for both a voltmeter and an ammeter. However, no owner or driver cares to carry two meters, so a combination instrument has been developed. Furthermore, to facilitate carrying, these are made as

pocket instruments, with a size but slightly greater than the ordinary watch. A combination instrument of this form is shown in Fig. 31. The cable connection is attached to a terminal not shown. Then, when it is desired to read the voltage of a cell, the cable connection is placed on one of its terminals, while the projecting terminal at the base of the meter—the one on the left marked volts—is touched to the other. The needle then indicates the voltage on the upper scale.

Similarly, to read the amperage, the same connections are made, with the exception that the right meter terminal, marked Amp., is used, and the reading on the lower scale taken. The dials of these instruments have a diameter of $1\frac{1}{4}$ inches.



Figs. 32 and 33. Ammeter and Voltmeter Sides of New Hoyt Multimeter with All Advantages of the Voltammeter, Wider Range, Less Chance for Trouble, Greater Accuracy, and Other Advantages

Courtesy of Hoyt Electrical Instrument Company, Penacook, New Hampshire

Multimeters. In an instrument of this kind the range of possible reading is, of course, limited, while there is a strong possibility of such a delicate device being ruined by accidentally using the wrong lower terminal. For instance, if it were desired to read the voltage of a powerful storage battery of, say, a 6-80 size, and if the ampere connection were made by mistake, the 80-ampere current flowing through the 30-ampere-limit meter would ruin it. In order to care for just this condition, and at the same time produce an instrument with a wider range, the multimeter, shown in Figs. 32 and 33, has been brought out. This consists of two separate meter movements placed in a single case, and set back to back. In using it, one side

with its own properly marked terminals is for reading voltages, while the other side with its terminals is used exclusively for amperages. As this is but slightly over two inches in diameter, it can be carried as readily as the other combination form. Although shown with an ampere range up to but 4, it can be made with a reading as high as 40, and higher readings can be taken with an external shunt, supplied with it.

Magnetometer. A development of the pocket meter for use with Ford cars is that shown in Fig. 34. This is called a magnetometer, and, as its name would indicate, is designed to show the condition of

the magneto on the Ford cars. In this, however, instead of being graduated in the ordinary units, volts and amperes, it has been graduated with an arbitrary scale, upon which the makers have indicated by letters four points, designated by the letters *P*, *M*, *G*, and *E*, to indicate poor, medium, good, and excellent. This instrument is intended to be placed on the dashboard, with one terminal grounded on the transmission case and the other attached to the insulated plug in the top of the Ford magneto. When this is done, the meter

Fig. 34. Hoyt Magnetometer—
Simple Device for Checking
up Ford Magneto Current
Courtesy of Hoyt Electrical Instru-
ment Company, Penacook,
New Hampshire

indicates by the proper letter the condition in the ignition system. The maker of the meter determined these points by a long series of tests. It should be pointed out, however, that at low speeds, even at normal efficiency, the indications will vary. Thus, up to 8 m.p.h. the average car will indicate poor; up to 15, medium; to 25, good; and above 25, excellent. One that will show *G* above 15 m.p.h. is considered to be in first-class condition.

With a reading of 18 amperes or over, through an ordinary pocket ammeter, a dry cell can be safely assumed to be in good enough condition to afford reliable ignition.

Care of Magneto. The best way to take care of a magneto is to leave it severely alone, except for regular oiling in the amounts and at the points stipulated by the manufacturer. The repair of the average magneto is a difficult task, and should be undertaken only by a competent expert, in a fully equipped repair shop.

CHASSIS REPAIRS

GENERAL INSTRUCTIONS

Making Gaskets. The art of cutting gaskets is a useful thing to know, for the removal of a paper gasket is usually accompanied by its breakage so it is rendered unfit for further use. A gasket, it might be explained, is a formed sheet of heavy paper, cardboard, or special material fitted between two surfaces of a joint which must resist the leakage of gases or liquids under pressure. By means of the bolts or screw threads which hold the two parts of the joint together, the gasket is compressed as the metal of the joint could not be, and by, or rather, in its compressed state, it resists the internal pressure.

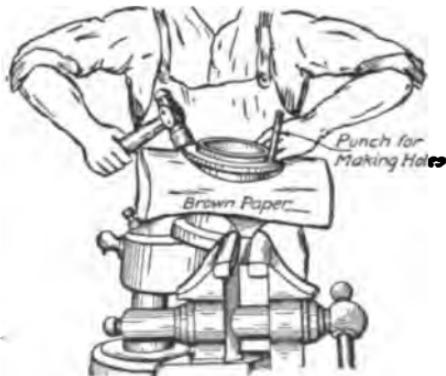


Fig. 35. Cutting Gaskets on the Parts with a Hammer is the Best and Quickest Method

this over the edge of the part for which the gasket is to be made, this being held in a vise so as to steady it and leave the handle free. Then go around the edges of the part, tapping lightly on the paper with the flat face of a hammer, holding the paper in position meanwhile, with the other hand.

This method is illustrated in Fig. 35, where a workman is shown making a gasket for the base of a cylinder. In this particular instance, there are needed also holes through the gasket for the cylinder bolts. These are made with the round or peen end of the hammer, or with the punch. When made, the punch is stuck into the hole to help hold the paper steadily. In this case, too, it was necessary to cut the inside of the gasket out first; then this material was removed, the sheet put back in place on the base of the cylinder, and work started on the exterior cutting.

If the hammer be held at a sharp angle with the edge of the part for which the gasket is being cut, each blow will cut through, or partly through, the paper. By repeating this operation enough times, going around the part meanwhile, the result is the finished gasket which will fit the desired place exactly.

Wiring. One of the parts of an old car which must be inspected most closely is the wiring. This is covered with insulation, which soon becomes either water-soaked if near the radiator or filling cap, or oil-soaked if too close to the lubricating means, or worn through at points where the motion of the car brings it into contact with sharp edges, and damaged in other ways. As soon as the insulation is worn off, ignition or other wiring is practically useless and must be replaced with new.

In replacing wiring, it pays to buy the best because the best has superior insulation and for this reason will stay in good condition

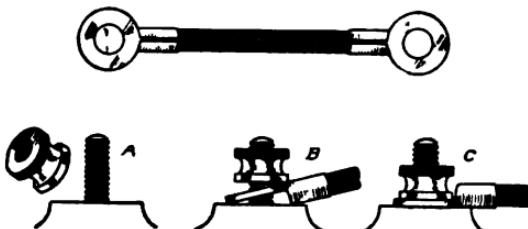


Fig. 36. Proper and Improper Method of Attaching Dry Battery Wires

for a much longer time. Also in replacing wiring, it is well to note that the various circuits must be figured out with care and precision, as the interchange of a pair of wires might short-circuit a battery, resulting in considerable damage.

Precaution with Battery Wires. In replacing battery wires there are a number of precautions to observe. Wires should not be cut too short; that is, give each wire plenty of length. This facilitates making neat terminals and coiling up the wire in a neat unobtrusive way. Where wires run across wood, they should always be nailed down, and where they traverse a considerable length of metal, it is well to fasten them down with tire tape, etc.

In replacing dry battery wires, it should be noted that there is a right and a wrong way of putting on the end of the wire. Usually this is made with a metal loop at the end, into which the tips of

the copper wire are looped and then soldered. This is thick on one side and stiff. If this thick stiff part be turned upward, the nut will go on right, screw down tightly, and make a good connection. If, on the contrary, this be turned downward, the nut will press it against the battery, but except for that point, it will not bear at any point and there will be a very poor contact. This as shown in Fig. 36, where *A* points out the battery terminal and nut, *B* the improper method—this bringing out the poor contact—and *C* the proper method with a good contact all around. The sketch above shows a short piece of ignition cable which has been fitted with suitable terminals of this kind. It is understood in making

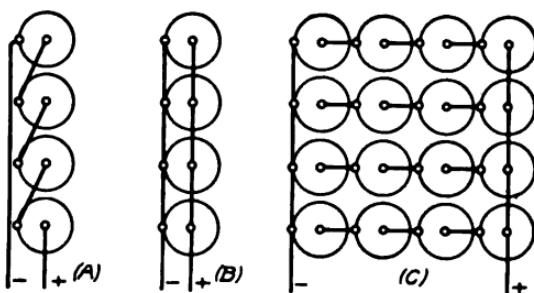


Fig. 37. Three Methods of Wiring Dry Cells: (A) Series for High Voltage; (B) Parallel for High Amperage; (C) Series-Multiple for Both High Voltage and High Amperage

this kind of a terminal that a drop of solder is put onto the end of the wire within the brass terminal fitting to hold the two together and improve the electrical connection and make it permanent.

Preferred Method of Wiring. When the wiring has been removed for renewal, it is time to think of improving the wiring method. With dry cells, this can be done by changing from either series or parallel connections to series-multiple. As will be pointed out, this requires more cells to start with and thus a large space for the cells, but the length of life is increased and the total cost is decreased.

In Fig. 37, *A* shows the usual series method, connecting from positive to negative, with the last negative at one end of the row forming the negative for the group, and with the last positive at the other end forming the positive for the group. This wiring gives high voltage, the voltage on one cell (about $1\frac{1}{2}$ volts) being multiplied by the number of cells, so that four cells give the 6 volts required to operate the coil.

At *B* is seen the usual parallel form of wiring, all the negatives being connected together to form the negative for the group and all the positives being connected together to form the positive for the group. This method produces the voltage of a single cell, but increases the pressure or amperage, the total being that of one cell multiplied by the number; that is, four cells, each testing 22 amperes, by this method of wiring would give 88 amperes at $1\frac{1}{2}$ volts. As pointed out 6 volts is required to operate the coil.

The form shown at *C* combines the above two methods and in a slightly modified manner has all of their advantages and none of their disadvantages. Here it will be noticed that four groups of four are each connected up in series, and then the negatives of the four groups are connected to form the negative for the whole unit, and the four positives to form the positive for the unit, the same as in parallel wiring; in short, each individual cell is wired up in its group by the series method and then the groups are wired up in parallel. The result is a voltage of 6, since each group has four cells of $1\frac{1}{2}$ volts wired in series, or $4 \times 1\frac{1}{2}$, or 6. The parallel wiring of the groups produces the amperage of one group times the number of groups, less a slight wiring loss. In the illustration this would be 4×22 , or 88, or say about 70 amperes. Obviously using four times as many cells this method gives equal voltage to the series form with quadrupled amperage, or equal amperage to the parallel form with quadrupled voltage; but what other advantages has it?

It has been proved by actual and accurate tests that cells wired in the last-named manner give a greater life and lessened cost than the same number of cells used a lesser number at a time and wired differently. For instance, one set of 5 cells wired in series lasted for 20 hours continuous service but four sets of 5 cells wired in series-multiple gave 170 hours of continuous service. That is, four times as many cells by a superior method of wiring gave $8\frac{1}{2}$ times as long a life. And with the greater amperage available through this service, it is apparent that service was better throughout the 170 than throughout the 20 hours. Another point is that one system means renewal each month, the other, renewal once a year.

CLUTCH TROUBLES AND REMEDIES

Layout for Cone Leathers. Clutches offer many chances for trouble, the wear and loss of power attendant upon this, slippery

or dry leather or weak springs being the principal factors. Weak springs may be cured by screwing up on the adjusting nut or bolt provided. Slippery leather may also be corrected by washing first with gasoline and then with water, finally roughing the surface with a coarse rasp and replacing only after the leather is thoroughly clean. Dry leather is fixed by soaking in water, or neatsfoot oil; it should be replaced while still moist, and copious lubrication will keep it soft.

The greatest problem in replacing a worn, charred, or otherwise defective leather lies in getting the right layout for the form of the new leather the first time. It must be remembered that the surface

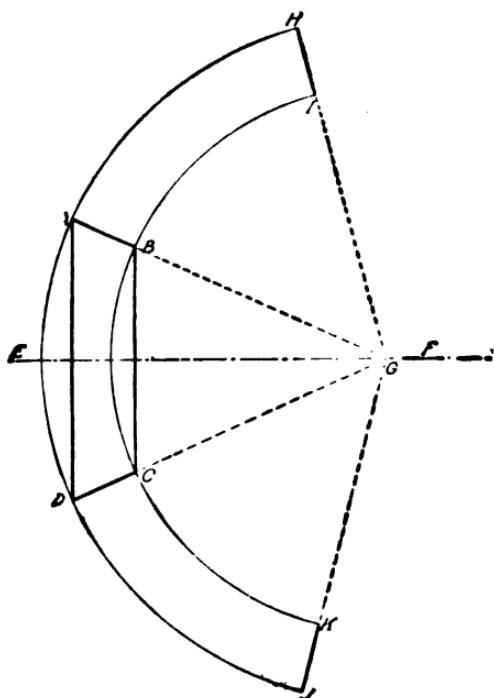


Fig. 38. Diagram Showing How to Cut Clutch Leathers

is a portion of a cone and, therefore, its development is not easy. It is attacked in this manner: Prepare the cone by removing the old leather and all rivets, cleaning out the rivet holes and providing new rivets. Measure the cone, taking the diameters at both the large and small ends, and the width. Take a large sheet of paper, and lay off upon it a figure similar to *ABCD* in Fig. 38, drawn to exact scale and having for its dimensions the three measurements just obtained, viz, the large and small diameters and width of the

cone. This figure represents the projection of the cone in a flat plane. Bisect the line *AD* and draw the center line *EF* at right angles to *AD*. Prolong the two tapered lines *AB* and *DC* until they meet the center line as at *G*.

This point *G* represents the apex of the cone if it were complete, and hence any circular arc drawn from this point as a center, and with the correct radius, will be a correct projection of the development of that portion of the conical surface. With *GA* and *GB* as radii, draw the two circular arcs *HADJ* and *IBCK*, also drawing

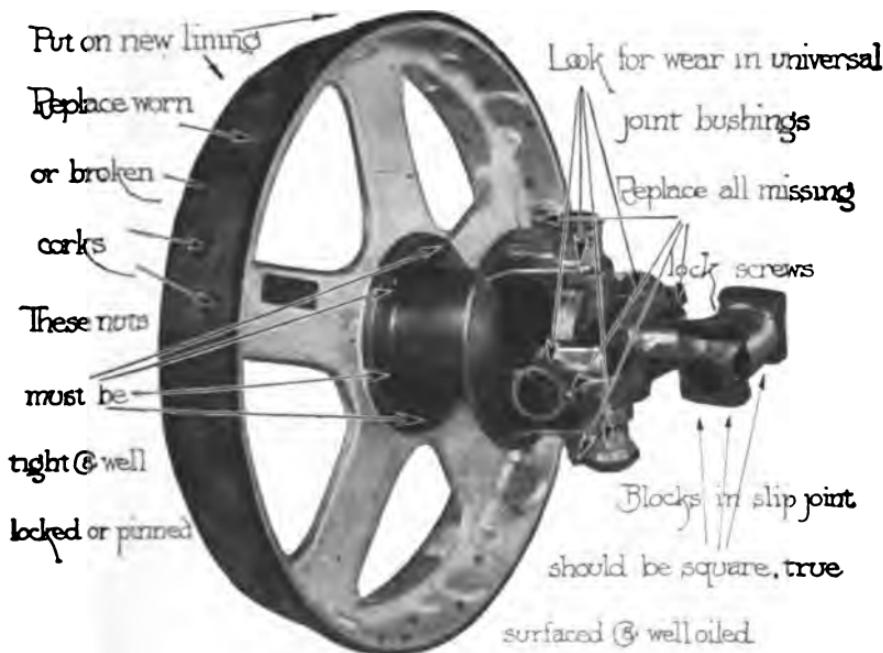


Fig. 39. Clutch Troubles Illustrated

the radial lines *HI* and *JK* to pass through *G*. The enclosed figure *HIBCKJDAH* may then be cut out and used as a pattern from which to cut out clutch leathers. If the distances *AH* and *DJ* be made approximately equal to or slightly more than *AD*, the pattern will a little more than encircle the cone clutch.

After the leather has been cut out, it should be prepared by soaking in water or oil, according as its surface is fairly soft or rather harsh. In either case, it must be well soaked, so as to stretch easily. In putting it on the cone, one end is cut to a diagonal, laid down on the cone, and riveted in place. Next, the leather is drawn down

tightly past the next pair of rivet holes which are then driven into place. This is continued until the strip is secured. The leather is now wetted again, for, if allowed to dry off immediately, the shrinking action will break it out at most of the rivet holes and render it useless. By drying out gradually, it can be made taut without danger.

In Fig. 39, several other common clutch troubles and their remedies are suggested, the parts shown in the illustration, however, being in excellent condition, in fact new.

Slipping Clutch. Slipping is the most common of clutch troubles. This is brought about in a cone clutch by oil, grease, or other

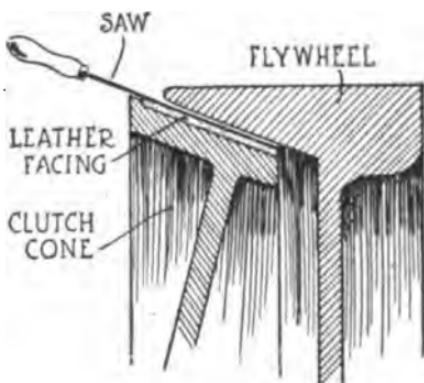


Fig. 40. Method of Roughing-Up Clutch Leather with Saw

slippery matter on the surface of the clutch, and can often be cured temporarily, by throwing sand, dirt, or other matter on the clutch surface, although this is not recommended. Many times, the clutch leather or facing becomes so glazed that it slips without any oil or grease on it. In that case it is desirable to roughen the surface by taking the clutch out, cleaning the sur-

face with kerosene and gasoline, and then roughing up the surface with a file or other similar tool.

In case it is not desired to take the clutch out, or when it is very inaccessible, the clutch surface may be roughened by fastening the clutch pedal in its extreme out position with some kind of a stick, cord, or wire, and then roughing the surface, as far in as it can be reached, with the end of a small saw, preferably of the keyhole type, about as shown in Fig. 40. Before starting this repair, it is well to soak the leather with neatsfoot oil, pouring this in the night before and allowing the leather to soak up as much of it as it will. This softens the leather and makes the roughening task lighter.

Many drivers make the mistake of driving with the foot constantly on the clutch pedal. This wears the leather surface and helps it to glaze quickly. The constant rubbing, due to slipping it frequently, also makes the leather hard and dry.

When a metal to metal, oiled clutch slips, the trouble usually is in the clutch spring which is too weak to hold the plates together. To remedy slipping with this type then, it is necessary to tighten up on the clutch spring adjustment.

Clutch troubles are not always so obvious. In one instance, the clutch slipped on a new car. In the shop, the clutch spider seemed perfect, also the spring, and properly adjusted, but to make sure, a new clutch was put in. Still the clutch slipped. To test it out still further, the linkage was disconnected right at the clutch and then it held perfectly, showing that the trouble was in the linkage. On examination one bushing was found to be such a tight fit that it would not allow the pedal to move freely enough to release fully. When this was relieved a little, the clutch acted all right.

Handling Clutch Springs. Clutch springs, like valve springs, mentioned previously, are mean to handle and compress, the best way being to compress and hold them that way until needed. For this purpose, a rig similar to that described for valve springs should be made but of stiffer, stronger stock. A very good one can be made from two round plates, one small, and the other of larger diameter with a pair of L-shaped bolts through it. The spring is placed between the two with the ends of the L's looped over the smaller plate, and then, by tightening the nuts on the bolts, the spring is gradually compressed.

Fierce Clutch. A "fierce" clutch is one that does not take hold gradually, but grabs the moment the clutch pedal is released. In a metal disk clutch, this is caused by roughened plate surfaces and insufficient lubricant, so that instead of the plates twisting gradually across one another as the lubricant is squeezed out from between them, they catch at once and the car starts with a jerk. On a cone clutch, this fierceness is produced by too strong a spring, too large a clutching surface in combination with a very strong spring, or a hard or burned clutch surface, or both.

Ford Clutch Troubles. There are now so many Fords in use that the average repair man feels justified in making special apparatus or tools to save time or work in Ford repairs. For one thing, the clutch disk drum frequently needs removal and this is a difficult job. By means of a simple rigging, however, consisting of a plate and a few bolts, it can be taken off in a few moments and with little

trouble. It will be noted from Fig. 41 that the rigging is but a modified form of wheel puller. It consists of a $\frac{1}{4}$ -inch plate of steel with three holes drilled in it for three bolts. The two outside ones have T-head ends and have to be specially made, and made carefully, as this T-head must slip through either one of the oval holes in the web of the drum. When this is done, it is straightened up so as to stand at right angles to the drum and is thus in a position to press firmly against the drum from the inside. There are nuts on the center bolt on both sides of the plate, the drawing showing only that on the outer end. When the T-bolts are in place, the center bolt, which is slightly pointed and preferably hardened on the end, is screwed down so as to come into contact with the end of the clutch shaft. After tightening this, the T-head bolts are tightened until they pull the drum off the shaft.

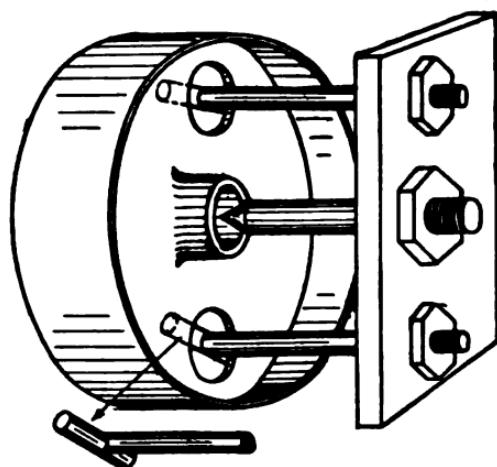


Fig. 41. Simple Rigging for Removing Ford Clutch Disk

the T-bolts are in place, the center bolt, which is slightly pointed and preferably hardened on the end, is screwed down so as to come into contact with the end of the clutch shaft. After tightening this, the T-head bolts are tightened until they pull the drum off the shaft.

Clutch Spinning. A trouble which is bothersome but not dangerous is clutch spinning. This is the name applied to the action of the male clutch member when it continues to rotate or spin after the clutch spring pressure has been released. With the male member connected up to the principal transmission shaft and gear, as is often the case, these members continue to rotate with it. This gives trouble mainly in gear shifting, for the member which is out of engagement is considered to be at rest or rapidly approaching that condition. When at rest, it is an easy matter to mesh another gear with this one; but when this one is rotating or spinning, it is not so easy, particularly for the novice.

Clutch spinning may be caused (1) by a defect in the design, in which case little can be done with it; (2) by a defect in construction—as in balancing, for instance, which can be corrected; or (3) it may be due to external causes, as for instance a bearing which has seized, due to a lack of lubricant, etc.

In any case, the best and quickest remedy is a form of clutch spinning brake. This may consist simply of a small pad of leather, or metal covered with leather, so located on the frame members that the male drum touches against it when fully released. Or it may be something more elaborate as to size or construction, or both. On many modern cars, in fact on practically all good cars, some form of clutch spinning brake is fitted.

TRANSMISSION TROUBLES AND REPAIRS

Transmission. Passing along to the transmission, Fig. 42 shows a plan of gearbox in which the disk clutch is also housed, the various possibilities for trouble or suggestions for its avoidance

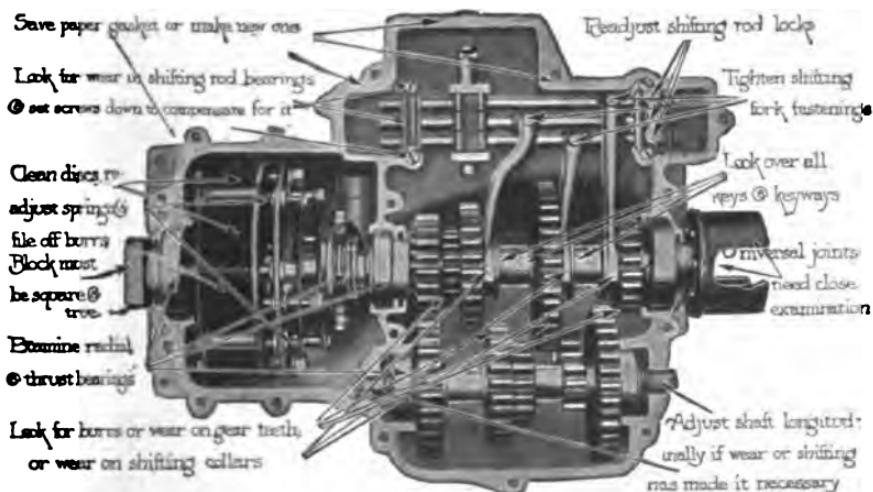


Fig. 42. Transmission Troubles Illustrated

being marked. In this type of clutch, the greatest possibilities lie in the burring of the disks or a lack of spring adjustment. If the former, the burrs can be filed off with a fine file, while the latter trouble is avoided by merely tightening the spring-adjusting springs, trying the effect of this and tightening again, until the correct and satisfactory position is obtained.

In transmission, the possibilities include the following: Burred teeth; gears worn where they slide along the shafts on keys or in keyways; looseness in the main bearings; and play in shifter rods or their locks. Where the gears clash, one against the other in shifting,

unless the faces of each have been chamfered and rounded off nicely and are well hardened at these points, there is liable to be set up a cutting action which gradually wears a high burr in one or both. When the two are in mesh, the burrs are on opposite sides and contacting with the meshing gear. This will make a continuous noise. Its remedy is the removal of the gear, the filing off smooth of all raised portions, the filing or grinding out of all low spots cut into the teeth, and subsequent hardening to make repetition impossible.

If the gears have worn at the center hole where they slide on the shaft, either in the round hole or at the keyway, this must be fixed at once. In the former instance, the gear can be bushed, and the bushing bored out to fit the shaft, while in the latter, a slightly larger key may be fitted in the shaft and the keyway may be recut to accommodate this. Where the keys have been let into the shaft, they may have worn in one spot or at the ends. If the wear is all in the key, this can be replaced with another of the same size, but made slightly harder in the process.

If the main bearings are of the roller type, the wear may be taken up by readjusting the position of the roller on the cone, but if they are of ball or plain bushing form, replacement is almost the only remedy, unless it happens that in the case of a plain bush, this is split, so that something may be filed off of the two contacting sides, and the holes trued out to this new size. In that case, the advice previously given under the subject of plain engine bearings will be applicable.

Play in the shifting rods may be traced to one of two things: Looseness at the connection of two rods, or of a rod and a lever; or looseness in the bearings. The former inevitably requires a new and slightly larger pin, driven into the place occupied by the previous member. Loose bushings will mean new ones if the trouble is serious, for this form is almost always of the solid and, thus, non-adjustable type. In many cases where wear occurs on a solid plain bearing used on the end of a plain round shaft, if peining can not be resorted to, as suggested previously, the shaft may be turned down a very little bit, say $\frac{1}{16}$ inch, the bushing turned out an equal amount, and a thin sleeve bushing made of this thickness all around, and forced into the previous member. This saves reboring the case, which is an expensive and difficult job, while both the shaft and bushing jobs are simple ones.

If a serious defect develops in the case, this may be cleaned out and welded. This is not a job for the amateur, but the closing of a simple crack, no matter how long, would be an easy proposition for the owner of a welding outfit; moreover, it would be a very short, quick job. Autogenous welding should always be resorted to as soon as a crack or break is detected, for this may save the expense and delay of a whole new case, the former costing, say, 50 cents to \$1 while the other easily may amount to \$50.

Noise in Gear Operation. One of the most common of transmission troubles is noise in the operation of the gears, generally a grinding sound. This is heard more in bevels than in spurs, but in old transmissions and on the lower speeds it is heard frequently. A good way to quiet old gears, after making sure that they are adjusted rightly and meshing correctly, is to use a thicker lubricant. If thick oil is being used, change to a half-oil half-grease mixture or preferably an all-grease mixture of fairly thick consistency.

In this respect the repair man or amateur worker may take a leaf out of the book of second-hand car men, who are said to "load" an old and very noisy transmission gear with a very thick almost hard grease in which is mixed some shavings, sawdust, cork, or similar deadening material. When this is done, a graphite grease is generally used, so that the shavings, cork, etc., would not show in case it was necessary to take off the gear-box cover. This material will fill up all the inequalities of the gears and shafts so that temporarily, everything fits more tightly, and in addition all the sounding-board, or echo, effect is taken out of the transmission case. This sounding-board effect is fully as important as the former, for many really insignificant noises are magnified, by poorly shaped gear cases, so as to appear very loud, indicating serious trouble which needs immediate attention, when such is really not the case.

Another source of gearset noise is a shaft out of alignment, caused either by faulty setting, by worn or loose bearings, or by yielding or cracking of the case. If it is properly set at one end and is out at the other, the trouble will be more difficult to find and remedy.

Heating. Heating is a common trouble, too, but usually this can be traced to lack of lubricant in an old car, of too large shafts or too small bearings in a new one. Sometimes the grease used will

cause heating, particularly when long runs are made with the transmission working hard. This is most noticeable when the grease or lubricant is of such a consistency that the gears simply cut holes in it but do not carry any around with them, or do not otherwise circulate the lubricant. This can be remedied by making it thicker so the gears will cut it better, by making it thinner so they will splash it more, or by changing the nature of it entirely to a form which is more sticky and will adhere more tightly.

Gear Pullers. One of the principal necessities for transmission work is a form of gear puller. These are like wheel pullers, except

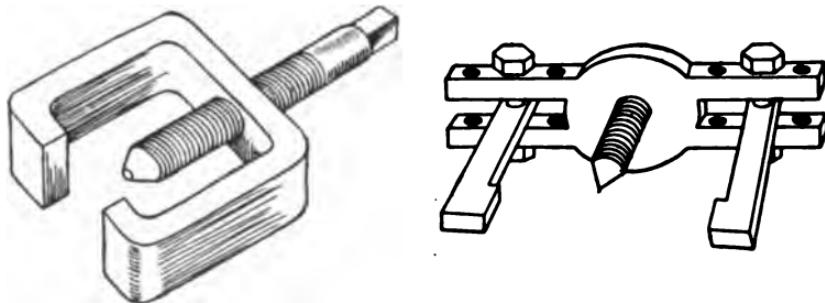


Fig. 43. Types of Gear Pullers

that they are smaller and more compact. In Fig. 43, a pair of these are shown. The one at the left is very simple, consisting of a heavy square bar of iron which has been bent to form a modified U. Then, a heavy bolt is threaded into the back of this or bottom of the U. This will be useful only on gears which are small enough to go in between the two sides of the puller, that is, between the sides of the U, which in use is slipped over the gear, the screw turned until it touches something solid as the end of the gear shaft, and then the turning continued until the gear is forced off.

While not as simple as this, the form shown at the right has the advantages of handling much larger gears, and also of being adjustable. As the sketch shows, this consists of a central member having slotted ends in which a pair of L-shaped ends or hooks are held by a pair of through bolts. Then there is a central working screw. To use, the hooks are set far enough apart to go over the gear, then slipped around it and hooked on the back. The central screw is turned up to the end of the shaft, and then the turning continued until the gear comes off. There are many modifications of these

two, in fact practically every repair shop in the land has its own way of making gear or wheel pullers. At any rate, every shop should have one.

Care in Diagnosis. The repair man should use a great deal of care in doping out or diagnosing the trouble in a transmission, for frequently what appears at first to be at fault turns out to be all right; or else something is back of the first trouble which must be corrected before a remedy can be applied. Thus, recently, a repair man figured that a new gear was needed to repair a transmission. This was received from the factory three days later, and when he started to put it in, he found that a bearing was defective; in fact, the defective bearing caused the wear in the gear. This necessitated a further delay of three days in order to get a new bearing.

Poor Gear Shifting. A common transmission trouble is poor gear shifting. This may be due to a number of different things. For one thing the edges of the gears may be burred so that the edges prevent easy meshing. When this is the case, any attempt to force the gears into mesh only burrs up more metal and makes the situation worse. Whether this is the trouble can be determined very quickly and easily by removing the transmission cover and feeling of the gears with the bare hand; the burred edges can readily be distinguished. If this is the only fault, the transmission should be taken down, the gears taken out and placed in a vise, and the burrs removed with a cold chisel and file.

Poor or worn bearings or a bent shaft or one not accurately machined may cause difficult shifting. If the bearings are worn, the difficulty of shifting will be accompanied by much noise, both in shifting and after. The bent shaft is more difficult to find and equally difficult to fix, a new shaft probably being the quickest and easiest way.

Sometimes the control rods or levers bind or stick so that shifting is very difficult. In case the gears are difficult to "find" or will not stay in mesh, the fault may be in the shifter rod in the transmission case. This usually has notches to correspond to the various gear positions, with a steel wedge held down into these notches by means of a spring. The spring may have weakened, may have lost its temper, may have broken, or for some other reason failed to work. Or with the spring in good working condition, the edges of the

grooves or notches may have worn to such an extent as to let the wedge slip out of, or over, them readily.

Handy Spring Tool. In the Ford transmission band assembly there are three springs, which it is difficult to assemble because of the trouble in holding so many things at once. To eliminate this trouble the tool shown in Fig. 44 can be constructed, this being made from flat bar stock. The handles, if they could be called that, are pivoted together and carry at one end a kind of flat jaw with three

notches. When the two of these are squeezed together by means of the screw and handle at the other end, the flat plates will hold three springs tightly enough so that all can be inserted in their



Fig. 44. Handy Spring Tool for Ford Assembly

proper positions at once, and by using but one hand. Tools of this kind, which save a great deal of the workman's time and thus save both time and money for the owner of the car, should, and in fact do, distinguish the good well-equipped repair shop and garage from the old-fashioned kind which is only in the business for the money, and not too particular how to get it.

In transmissions of the planetary type, there is little or no trouble except with the bands. If these are loose, the gears will not engage and the desired speed will not result. If they become soaked with grease, oil, or water, they will not work as well as if kept clean, and in the case of excessive grease, will slip continually. If the band lining becomes worn, it should be treated just as a brake lining is. When inspected for wear and found not badly worn but slippery, it may be cleaned in gasoline and then in kerosene, after which a saw, hacksaw, or coarse file may be used to roughen it. Sometimes greasy bands can be fixed temporarily—say, enough to get the car to a place where tools, materials, and facilities for doing the work are available—by sprinkling on powdered rosin or fuller's earth. The former should be used sparingly because it will cause the band to bite or grab hold when forcibly applied, and at times has been known to cut into and score a cast iron drum.

FINAL DRIVE

Driving Shaft. From the gearbox to the rear axle the power, in the majority of cases, is transmitted by a long shaft. This may have either one or two universal joints in its length. The purpose of these is twofold: to permit the rise and fall of the rear axle relative to the rest of the car, and to allow similar side sway in which the whole rear construction participates. These joints are covered usually with leather casings which are packed with grease. These keep out the dirt and, consequently, lessen the wear, and also lubricate the moving parts of the joints. A secondary function of the casings is to render these joints noiseless. If a car is not equipped with them, it is advisable for the owner to purchase them.

The shape of these casings when opened out flat would be not unlike that of two bottles with their flat bottoms set together, that is, narrow at the top and bottom and wider at the middle. All along both edges are eyelets for the lacing. The enlarged center fits around the joint, while the small ends encircle the respective shafts. To apply the casing, one end is placed around the shaft on one side of the joint and the lace started; then the lacing proceeds, gradually drawing the ends together and around the joint. When this has been completed and before the last end is closed, the whole is shoved back along the first shaft a little way and the center portion half filled with a heavy grade of transmission grease. This done, the glove is pulled back into place and the work of lacing completed around the second shaft. Both ends should be laced as tightly as possible while the middle part should be loose.

REAR-AXLE TROUBLES

Jacking Up Troubles. Many axles have a truss rod under the center and this is in the way when jacking; however, this can be overcome. Make from heavy bar iron a U-shaped piece like that shown in Fig. 45 on top of the jack, making the width of the slot just enough to admit the truss rod. The height, too, should be as little as will give contact with the underside of the axle housing.

Substitute for Jack. A good substitute for a jack is a form of hoist, Fig. 46, which will pick up the whole rear end of the car at once. This not only saves time and work, but holds the car level while jacking one wheel does not. Moreover, with a rig of this kind

the car can be lifted so easily and high, that it is easy to work under. The usual hoisting blocks are very expensive, but the above hoist

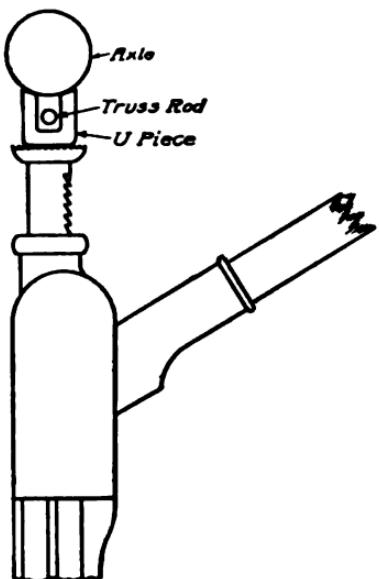


Fig. 45. Simple Arrangement for Avoiding Rear-Axle Truss Rod

can be easily made by the ingenious repair man. This is made from an old whiffletree, to the ends of which are attached a pair of chains. For the lower ends of the chains, a pair of hooks are made sufficiently large to hook under and around the biggest frame to be handled; with the center of the whiffletree fastened to the hook of a block and tackle the hoist is complete. By slinging the hooks under the side members of the frame at the rear, it is an easy matter to quickly lift that end of the chassis any distance desired.

Workstand Equipment. Next to raising the rear axle, the most important thing is to support it in its elevated position. To leave it on jacks is not satisfactory, for they will not raise the frame high enough, and furthermore, they are shaky and may easily let the whole rear end fall over, doing considerable damage. With the overhead hoist, the chains or ropes are in the way. So a stand is both a necessity and a convenience. In Fig. 47 several types are shown. *A* is essentially a workstand, intended to hold the axle and part of the propeller shaft while doing repair work thereon. It consists of a floor unit or base, built in the form of an *A*, with six uprights

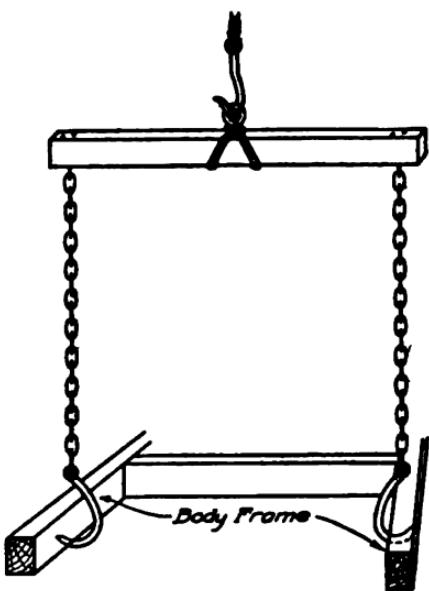


Fig. 46. Simple Automobile Frame Hoist

let into it, preferably mortised and tenoned for greater strength and stiffness. Then, the four rear uprights are joined together for addi-

tional stiffness and rigidity. If casters are added on the ends it can be more conveniently handled around the shop.

The forms *B* are for more temporary work and consequently need not be so well or so elaborately made. The little stand *C* is a very handy type for all-around work. Stands of this kind with the top surface grooved for the axle, are excellent to place under cars which have been put in storage for the winter.

The stand *D* is, like *A*, a workstand pure and simple. In this however, the dropped end members allow supporting the axle at those points, while the elimination of central supports gives plenty of room for truss rods. This type of stand would preferably be made from metal, pressed steel or small angle irons being very good. Every repair shop should have a considerable number and variety of stands,

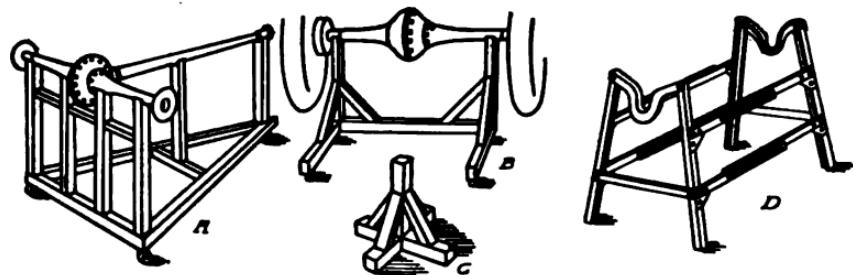


Fig. 47. Types of Handy Stands for Rear-Axle Repair Work

made as the work demands them, and made just to fit this particular class of work.

Locating Trouble. Many times, a car may be brought in for rear axle repair on which the repair man cannot find any trouble. Many an axle often develops an elusive hum, or grinding noise, which not only defies location, but is not continuous. The writer had such a one at one time, and was sure that the bevel gears were out of alignment and were cutting one another. It was a low pitched whine which was not apparent at low speeds, but began to be heard around 18 to 20 miles an hour, and at times was very apparent. The noise was very annoying, but tearing down the rear construction showed absolutely no trouble so the noise could not be at that point. Sometime later the noise was definitely located in a pair of worn speedometer gears on the right end of the front axle. That is, the supposed rear axle trouble was not on the rear axle at all.

A good way to listen to rear axle hums out on the road is to lay back over the rear end of the car, Fig. 48, with the head against the top of the seat and projecting over slightly, and with the hands cupped in *front* of the ears, so as to catch every noise that arises. The larger sketch shows the general scheme, the small inset giving the method of holding the hands.



Fig. 48. Listening for Rear-Axle Noises

speeds, and coasting, this noise can be tied to something more definite, some fixed method of happening. In advance of actual repair work, including tearing down the whole axle, the gears can be adjusted. This can generally be done from outside the axle casing and without

a great deal of work. If the adjustment makes matters worse, it can be reversed, or if it improves the situation, the adjusting can be continued, a little at a time, until the noise gradually disappears.

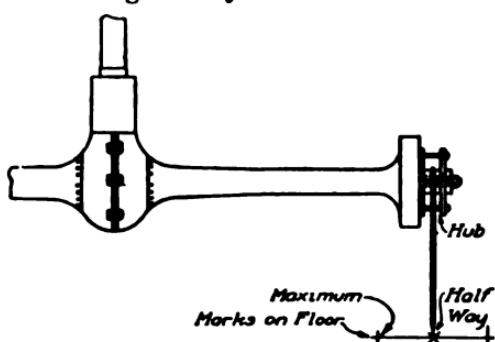


Fig. 49. Diagram Showing Method of Checking Up Ford Axles

without taking down the whole construction. The principal point is to find out how much and which way the axle is bent. By removing the wheel on the bent side, and placing on the axle

Checking-Up Ford Axles. Many cases of bent Ford rear axles can be fixed

end the rig shown in Fig. 49, the extent of the trouble can be indicated by the axle itself. The rod is a long, stiff, iron one, fastened permanently to an old Ford hub, with its outer end pointed. The rig is placed on the axle and held by the axle nut, but without the key, as the axle must be free to turn inside the hub. With the pointed end of the rod resting on the floor, and with high gear engaged, have some one turn the engine over slowly, so as to turn the axle shaft around. As it revolves, the hub will be moved and the pointed end on the floor will indicate the extent of the bend. By marking the two extreme points, and dividing the distance between them, the center is found. Then a rod can be used as a bar to bend the axle until the pointed rod end is exactly on the center mark. A little practice with this rig will enable a workman to straighten out a Ford rear axle in about the time it takes to tell it.

BRAKE REPAIRS

Brake Linings. The brakes now are usually placed side by side within the drum attached to the wheel, as shown in Fig. 50. This

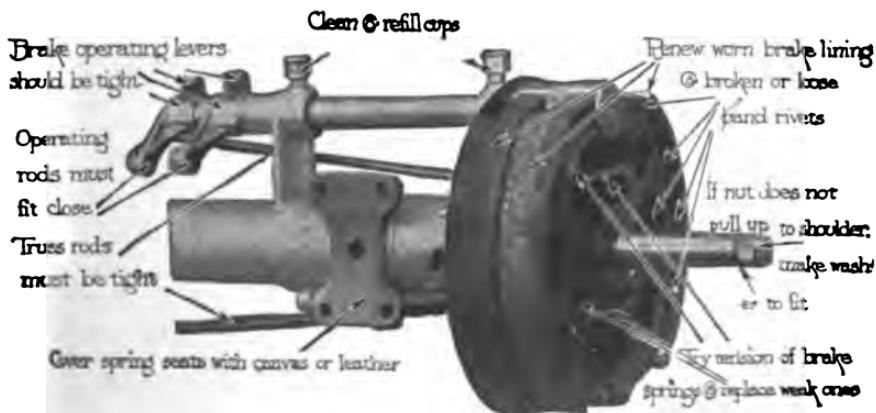


Fig. 50. Brake Troubles Illustrated

shows a semi-floating form of rear axle with the two sets of brakes and operating shaft and levers. A number of suggestions are placed upon this, among which will be noted this: "Renew worn brake lining and broken or loose rivets."

When a brake lining is worn, the proceeding is much the same as with a clutch leather previously described, with the exception

that, whereas the latter must have a curved shape, the former can be perfectly straight and flat. This simplifies the cutting, but as most brake linings are made of special, heatproof, asbestos composition which is made in standard widths to fit all brakes, the cutting of leather brake bands is not often necessary.

Dragging Brakes. Probably the first trouble in the way of brakes is dragging, that is, braking surface constantly in contact with the brake drum. This should not be the case; usually springs are provided to hold the brake bands off the drums. Look for these springs and see if they are in good condition. Or one or both of the brake bands may be bent so that at a single point the band touches the drum.

Another kind of dragging is that in which the brakes are adjusted too tightly—so tightly in fact that they are working all the time. In operating the car, there will be a noticeable lack of power and speed, while the rear axle will heat constantly. This can be detected by raising either rear wheel or both by means of a jack, a quick lifting arrangement, or a crane, and then spinning the wheels. If the brakes are dragging, they will not turn freely.

All that is needed to remedy this trouble is a better adjustment. For the new man, however, it is a nice little trick to adjust a pair of brakes so that they will take hold the instant the foot touches the pedal, that they will apply exactly the same pressure on the two wheels, and yet will not run so loose as to rattle or so tight as to drag.

Dummy Brake Drum Useful. Where a great deal of brake work is to be done, particularly in a shop where the greater part of

the cars are of one make, and the brakes consequently, all of one size, a great deal of time and trouble can be saved by having a set of test drums. An ordinary brake drum with a section cut out so that the action inside may be observed, is all that is

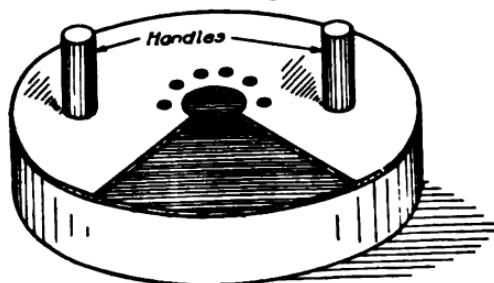


Fig. 51. Dummy Brake Drum for Adjustment Work

necessary, except that it should be mounted suitably. As shown in Fig. 51, it is well to fit a pair of handles to the brake drum to assist in turning the drum when the adjustment is being made. The real

saving consists of the work which is saved in putting on and taking off the heavy and bulky wheel each time when the adjustment is changed. The test drum is put on instead, and being small and light, and equipped with handles, it is easily and quickly lifted on and off. This enables the workman to make a better and more accurate adjustment of the brake than he would if the heavy wheel had to be handled, while the cut-out section in the test drum enables him to see the inside working also, and thus correct any defects or troubles at this point.

Eliminating Noises. Many times the brake rods and levers wear just enough to rattle and make a noise when running over rough roads or cobblestone pavements, but hardly enough to warrant replacing them. The replacement depends on the accuracy with which they work, the age and value of the car, and the attitude of the owner. In a case where the owner does not desire to replace rattling rods, this can be corrected by means of springs, winding with tape, string, etc.

If the rod crosses a frame cross-member or is near any other metal part and its length or looseness at the ends is such that it can be shaken into contact there, a rattle will result at that point. This can be remedied or rather deadened by wrapping one part or the other. For this purpose, string or twine can be used as on a baseball bat or tennis racket handle, winding it together closely so as to make a continuous covering. Tire or similar tape may also be utilized. When this is done, it is necessary to lap one layer partly over the next in order to keep the whole tight and neat. Tire tape holds together and has the additional advantage of giving a greater thickness when desired and thus greater resistance to wear. If none of these remedies are available or sufficient, burlap or other cloth in strips may be used, putting this on in overlapping layers the same as the tape.

The springs should be put on in such a way as to take up the lost motion and hold the worn parts closer together. The rattle occurs when the movement of the car alternately separates and pulls together the two parts, a noise occurring at each motion. The spring should be put on so as to oppose this motion, acting really as a new bushing or pin, the pull coming first upon the spring and then upon the bushing or pin pulled up tight.

FRAME TROUBLES AND REPAIRS

The more usual troubles which the repair man will encounter are sagging in the middle; fracture in the middle at some heavily loaded point or at some unusually large hole or series of holes; twisting or other distortion due to accidents; bending or fracture of a sub-frame or cross-member; bending or fracture at a point where the frame is turned sharply inward, outward, upward, or downward.

Sagging. A frame sags in the middle for one of two reasons: either the original frame was not strong enough to sustain the load, or the frame was strong enough normally, but an abnormal load was carried which broke it down. Sometimes a frame which was large enough originally, and which has not been overloaded, will fail through crystallization, or in more common terms, fatigue of the steel. This occurs so seldom, and then only on very old frames, that it cannot be classed as a "usual" trouble; moreover, it cannot be fixed.

When a frame sags in the middle, the amount of the sag determines the method of repair. For a moderate sag, say $\frac{1}{4}$ to $\frac{1}{2}$ inch, a good plan is to add truss rods, one on either side. These should be stout bars, well anchored near the ends of the frame and at points where the frame has not been weakened by excessive drilling. They should be given a flattened U-shape, with a couple (or more) uprights down from the frame between them. The material for them should be stiff enough and strong enough to withstand bending, and should be firmly fastened to the underside of the frame. The truss rods should be made in two parts with a turnbuckle to unite them, the ends being threaded right and left to receive the turnbuckle. When truss rods are put on a sagged frame, it should be turned over and loaded on the under side; then the turn-buckles should be pulled up so as to force the middle or sagged part upward a fraction of an inch—say $\frac{1}{8}$ to $\frac{1}{4}$ inch—and then the frame turned back, the other parts added, and the whole returned to use. A job of this kind which takes out the sag so that it does not recur is a job to be proud of.

Fracture. Many a frame breaks because too much metal was drilled out at one place. Fig. 52 shows a case of this kind. The two holes were drilled one above the other for the attachment

of some part, and were made too large. They were so large, that at this particular point there was not enough metal left to carry the load, and the frame broke, as indicated, between the two holes and also above and below. A break of this kind can be repaired in two good ways. The first and simplest—as well as the least expensive—is to take a piece of frame 10 to 12 inches long of sufficiently small section to fit tightly inside this one. Drive it into the inside of the main frame at the break, rivet it in place firmly throughout its length, and then drill the desired holes through both thicknesses of metal.

This is not so good as welding. A break of this kind can be taken to a good autogenous welder who will widen out and clean the crack, fill it full of new metal, fuse that into intimate contact with the surrounding metal, and do so neat and clean a piece of work that one would never know it had been broken. When a welding job is done on a break like this, and no metal added besides that needed to fill the crack, subsequent drilling should be at an angle, to avoid a repetition of the overloading condition. In the figure, the dotted lines suggest the drilling. By staggering the holes in this way, there is a greater amount of metal to resist breakage than would be the case with one hole above the other—a method which might preferably have been used in the first place.

So much welding is done now, and so many people know of its advantages, that every repair shop of any size should have a welding outfit. A frame job is essentially an inside bench job, but a large number of cases of welding could be done directly on the car outside the building, particularly in summer when the outside air and cooling breezes are desirable. So, it is well to construct a small truck on which to keep the oxygen tank, acetylene cylinder, nozzle for working, and a fire extinguisher. One form of a truck is shown in Fig. 53, this being a simple rectangular platform with casters, a handle, and a rack to hold the tanks. It saves many a step and is

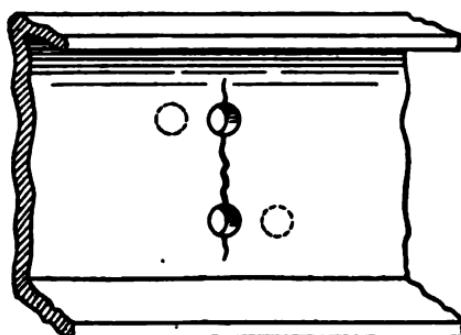


Fig. 52. Reborning Cracked Steel Channel

particularly convenient in summer months. This outfit is essentially a home-made affair but the gas-welding and electric-welding manufacturing companies have designed small outfits especially for automobile repair work, which would be preferable to Fig. 53, especially where the amount of repair work warrants a reasonable expenditure for a welding outfit. A description of both gas and electric outfits and instructions for their use are given in the article entitled "Welding for Automobile Repair Work."

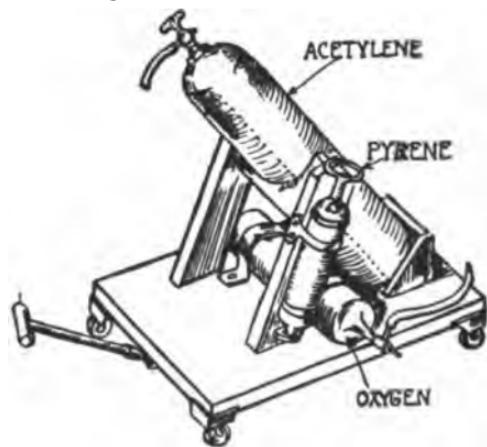


Fig. 53. Handy Oxy-Acetylene Outfit

Truss Rods. Truss rods

hold the wheels in their correct vertical relation to the road surface and to one another. If through wear or excessive loading, the axle sags so that the wheels tip in at the top, presenting a knock-kneed appearance, the truss rods must be tightened up so as to remedy this. Usually they are made with a turnbuckle set near one end, a locknut on each side preventing movement. The turnbuckle is threaded internally with a right-hand thread on one end and a left-hand on the other, so that a movement of the turnbuckle draws the two ends in toward one another, shortens the length of the rod, and thus pulls the lower parts of the wheels toward one another, correcting the tipping at the top.

To adjust for this trouble, loosen both locknuts, remembering that one is right-handed and the other left. Then, with the wheels jacked clear of the ground, tighten the turnbuckle. A long square should be procured or made so that the wheel inclinations may be measured before and after. Placing the square on the ground or floor, which should be selected so as to be perfectly level, the turnbuckle should be moved until the tops appear to lean outward about one-half inch—some makers advise more.

It should be borne in mind that even if the wheels and axle do not show the need of truss rod adjustment, if this rod be loose, it will become very noisy and rattle a great deal for the rear axle

sustains a great amount of jouncing. Moreover, this noise and rattle if not taken up will cause wear, which later cannot be taken up.

Frame Strengthening Rods. Similarly, whenever any part of the frame shows indication of weakening, a rod can be used to strengthen it. Thus the front of the frame often suffers in collisions

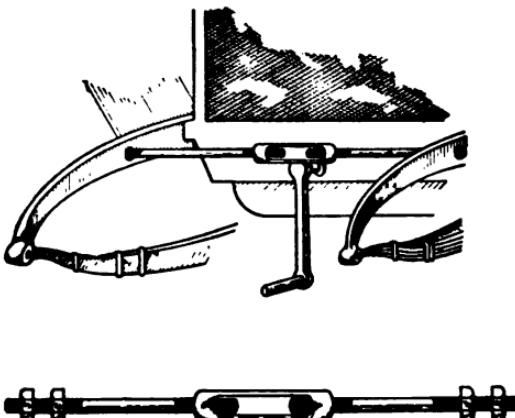


Fig. 54. Adding a Truss Rod to the Front of a Weak or Damaged Frame to Strengthen It and Preserve the Radiator

or indicates weakness. If this be allowed to continue, it will warp the delicate and expensive radiator and cause heating troubles. As pointed out in Fig. 54, this can be remedied by a plain straight rod about the width of the frame plus 2 inches, and threaded for about 3 inches on each end. The turnbuckle in the center is optional. When putting this in place, the inner nuts must be screwed on first far enough to allow of putting the rod in place. Then these are screwed out again until they bear against the frame from the inside. Next the outside nuts are put on and screwed into place against the outside of the frame. By loosening the inner ones and tightening the outer ones the frame can be pulled in as desired. When the rod is once put in place, the turnbuckle allows of making subsequent changes more quickly. Otherwise, it is not necessary.

FRONT AXLE TROUBLES AND REPAIRS

Alignment of Front Wheels Troublesome. The lack of alignment of front wheels gives as much trouble as anything else in the front unit. This lack not only makes steering difficult, inaccurate,

and uncertain, but it also influences tire wear to a tremendous extent. As Fig. 55 indicates, even if the rear axle should be true with the frame, at right angles to the driving shaft, and correctly placed crosswise—that is, correct in every particular with the shafts both

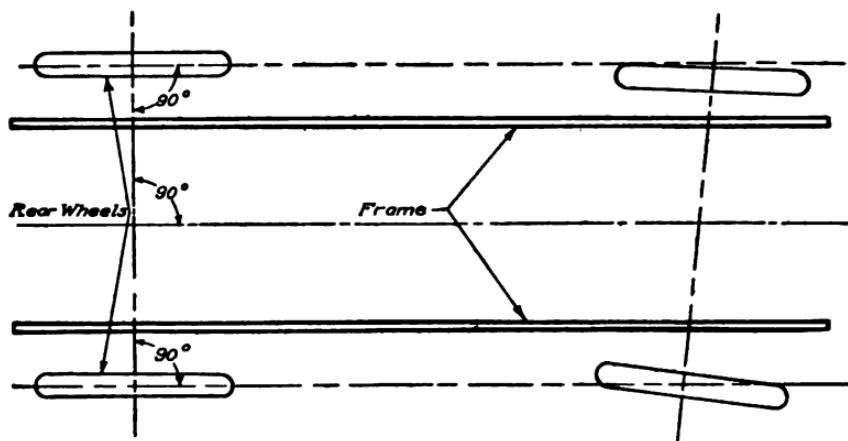


Fig. 55. Diagram Showing Front Axle and Wheels Out of True

straight so that the wheels must run true—the fronts may be out with the frame, out of track with the rears, or out with respect to one another.

Now in order to know about the front wheels, they should be measured, and while this sounds simple, it is anything but that. In the first place there is little to measure from, or with. A good starting place is the tires, and a simple measuring instrument is the one shown in Fig. 56. This consists of a rod about $\frac{1}{4}$ inch in diameter and about three feet long fitted into a piece of pipe about two feet long, with a square outer end on each and a set screw to hold the measurements as obtained. By placing this between the opposite sides of the front tires, it can be ascertained whether these are par-

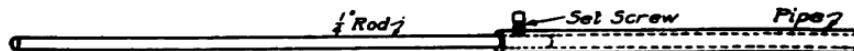


Fig. 56. Simple Measuring Rods for Truing-Up Wheels

allel, and whether they converge or diverge toward the front. But knowing this, the driver or repair man is little better off than before, because this may or may not be the practice of the makers of the car, and it may or may not cause the trouble.

In short, a more accurate and more thorough measuring instrument is needed, Fig. 57. Such a one can be bought, but a similar outfit can be made from $\frac{3}{8}$ -inch bar stock, using thumb nuts where the two uprights join the base part, and also at the two points, or scribes, on these uprights. Having the floor to work from, the

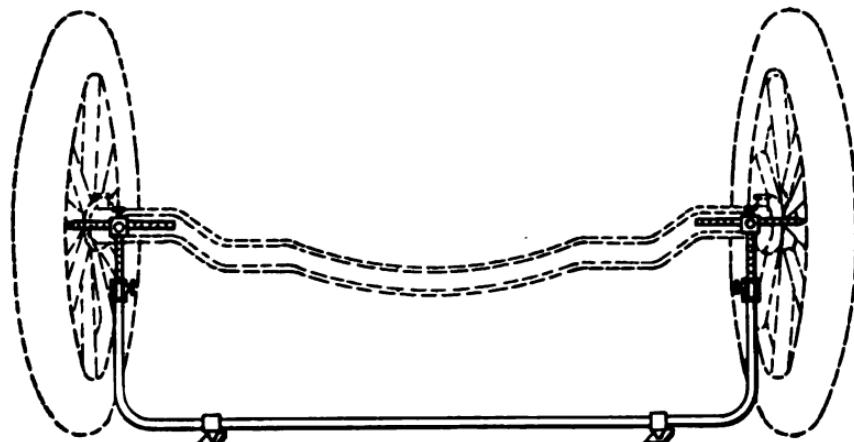


Fig. 57. Accurate Measuring Rod for Truing Up Wheels. Better Design than Fig. 278

heights can be measured, and thus the distance between tires may be taken on equal levels. Thus, a bent steering knuckle can be detected with this apparatus. Similarly, the center line and frame lines of the car can be projected to the floor, and by means of the instrument, it can be determined whether the axle is at a perfect right angle with these, and whether the wheels are perfectly parallel. Given the frame line, too, it can be determined whether the wheels track with one another.

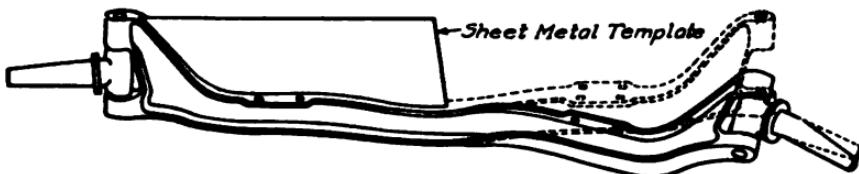


Fig. 58. Template for Showing if Axle Is Bent

Straightening an Axle. When an axle is bent, as in a collision, a template is useful in straightening it. This can be cut from a thin sheet of metal, light board, or heavy cardboard. It is an approximation at best and should be used with great care. Fig. 58 shows such a template applied to an axle which needs straightening.

When the axle is bent back to its original position, a pair of straight edges laid on top of the spring pads will be of great assistance in getting the springs parallel, as the worker can look across the straight edges with considerable accuracy. This is indicated in the

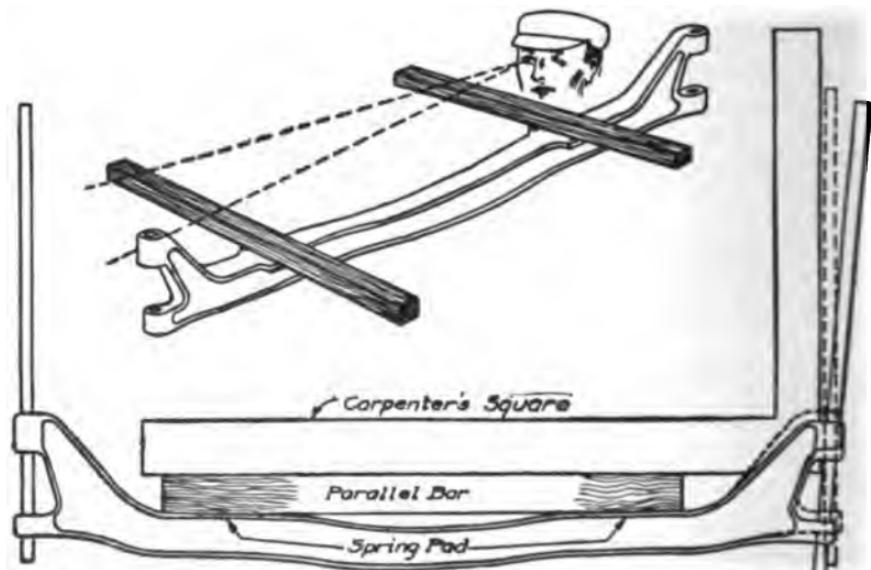


Fig. 59. Diagram Illustrating Method of Truing-Up an Axle

first part of Fig. 59 which shows the general scheme. It shows also how the axle ends are aligned, using a large square on top of a parallel bar, but of course this cannot be done until the last thing, at least not until the spring pads are made parallel.

SPRING TROUBLES AND REMEDIES

Lubrication. Experience tells us that the average repair man is apt to have more call to lubricate the leaves of a spring than any other one thing in connection with springs. True, they lose their temper, sag, and show signs of losing their set; plates break in the middle, at the bolt hole, and near the ends of the top plate; and inside plates break in odd places. More frequently, springs make an annoying noise, a perceptible squeak because the plates have become dry and need lubricating. When this happens, and the up or down movement of the car rubs the plates over one another, dry metal is forcibly drawn over other dry metal with which it is held in close contact; naturally, a noise occurs.

To take care of this job, it is well to construct a spring leaf spreader. Of course, the job is best done by jacking up the frame, dismounting the spring entirely, taking it apart and greasing each side of each plate thoroughly with a good graphite grease. Sometimes spring inserts are used; these are thin sheets of metal of the width and length of the spring plates, having holes filled with lubricant over which is a porous membrane.

For the ordinary spreading job, the plates must be pried apart and the grease inserted with a thin blade of steel, for instance, a long-bladed knife. To spread the leaves, jack up the frame so as to take off the load, then insert a thin point and force it between a pair of leaves. In Fig. 60, two forms of tools for doing this forcible

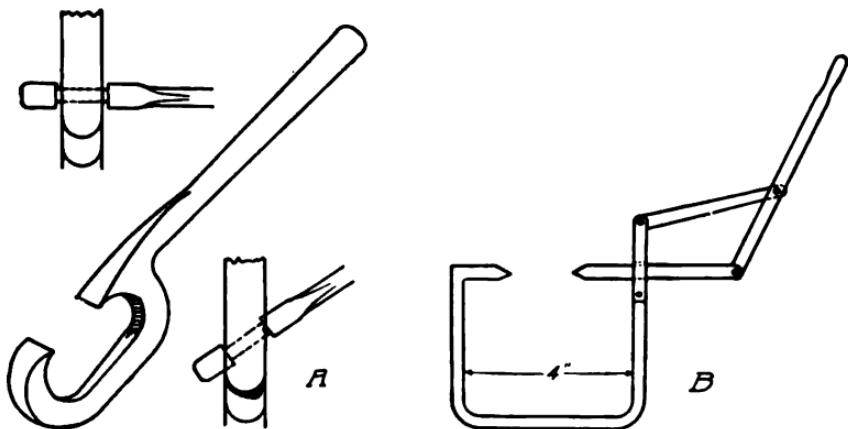


Fig. 60. Handy Tools for Spreading Spring Leaves to Insert Lubricant

separation are shown. The first is a solid one-piece forging with the edges hardened. It is used by sliding the edges over the ends of the spring leaf, then giving it a twist as shown in the figures. The second tool forces the leaves apart by drawing back the handle.

Tempering or Resetting Springs. When springs lose their temper or require resetting, it is better for the average repair man to take them to a spring maker; this is a difficult job, requiring more than ordinary knowledge of springs, their manufacture, hardening, annealing, etc. When springs are in this condition, they sag down under load and have no resiliency. If a great many springs are handled, a rack like that shown in Fig. 61 is well worth making.

Broken Springs. When springs break, there is but one shop remedy, a new plate or plates. But when they break on the road,

it is necessary to get home. When the top plate breaks near the shackled end, repair this sufficiently to get home by using a flat wide



Fig. 61. Simple and Well-Designed Spring Rack

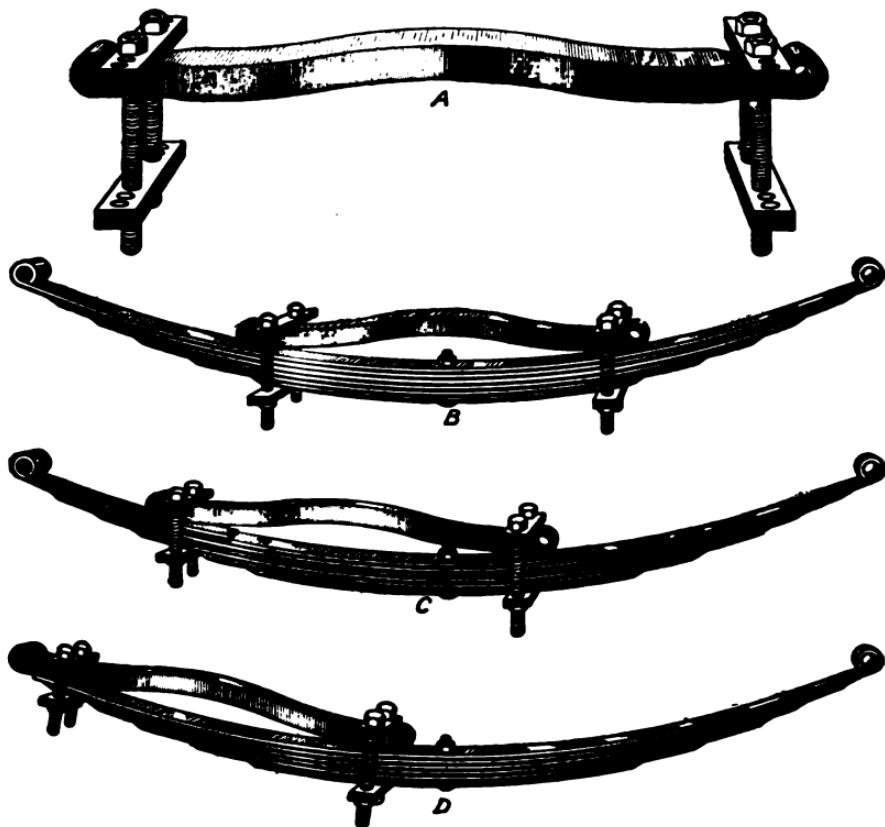


Fig. 62. Steel Bar Carried for Spring Repairs

bar, Fig. 62, with a hole in one end big enough to take the shackle bolt; bolt this to the spring in place of the end of the broken leaf.

RUNNING GEAR REPAIRS

STEERING MECHANISM TROUBLES AND REPAIRS

Lost Motion in Wheel. The most common steering mechanism trouble is lost motion in the wheel, that is, when the wheel is turned, it must be moved a considerable distance before there is any result. This free turning proves that there is considerable wear somewhere, and usually this wear is in the wheel and in its fastening to the steering post; sometimes it is within the gear itself, or partly in both. A certain amount of play or lost motion is unavoidable, and if the movement of the wheel before other parts move does not exceed $\frac{1}{2}$ or $\frac{3}{8}$ inch, the amateur should not attempt to take it out.

Removing Wheel. When the wear is in the wheel itself and in its fastening to the post, the wheel must be removed. It may come off easily but if not, use one of the many wheel or gear pullers, or substitutes previously described, or construct one specially for pulling steering wheels. This should have pivoted and detachable side members which can be slipped over the largest or smallest hub with ease. It should remove the wheel without marring.

Refitting Key. Once removed, the fastening should be examined. Many times this is only a square key, half in the wheel and half in the post, in which case, it can be replaced by a rectangular key, thicker than it is wide. By having a larger size in one direction the keyseats in both wheel and post can be recut and made to fit very accurately. The seats should be made a little small if anything, and the key driven into place. The tighter it fits, the less lost motion.

Correcting Backlash in Gear. With the key fixed, or if it needs no attention, the gear should be examined. Perhaps the gears have worn enough to develop a little backlash. In this case, most if not all the lost motion can be taken out by readjusting the gears. If they are of the sector type, set the sector in closer to the worm by using the eccentric bushings on the sector shaft. If they are of the bevel-gear type, set the gears in closer together, moving whichever one has a sideway adjustment. If they are of the worm and full gear type, either move the gear closer to the worm, as in the sector form, or take it off and turn it. If the shaft on which the lever is placed is equipped with a square, this gives four positions, and the gear can be turned through 90 degrees, or a right angle; if the lever is

put on a hexagon shaft the gear can be turned through $\frac{1}{6}$ of a full circle, or 60 degrees, giving six different positions; or if the shaft is a taper, the lever can be moved over one tooth at a time.

WHEEL TROUBLES AND REPAIRS

The removal and handling of wheels presents probably the biggest problems in connection with them. True, broken wheels give the repair man a good deal to think about, but the quick accurate handling of jobs in which a broken wheel figures depends more upon possessing and knowing how to use certain equipment than anything else; the operations are so simple that they require no particular skill or knowledge.

Wheel Pullers. In handling wheels a wheel puller of some form is generally a necessity; wheels are removed so seldom that they are likely to stick, and they get so much water and road dirt that there is good reason for expecting them to stick or to be rusted on. This means the application of force to remove the wheel. For this purpose a wheel puller is needed, and a number of these have been illustrated and described previously, as gear pullers, steering wheel pullers, etc. Any of these devices which are large enough to grasp the spokes of the wheel and pull the latter outward and, at the same time, press firmly against the protruding axle shaft, will do the work very satisfactorily.

Sometimes, however, while owning a puller, a wheel breaks down on the road where this is not available, or the repair man is called without being told the trouble, so that he does not bring the puller with him. In such cases, the repair man must improvise some kind of a puller out of what he has on hand. Everyone carries a jack, so it is safe to assume that one of these will be available as well as some form of chain. If a chain of large size is not available,

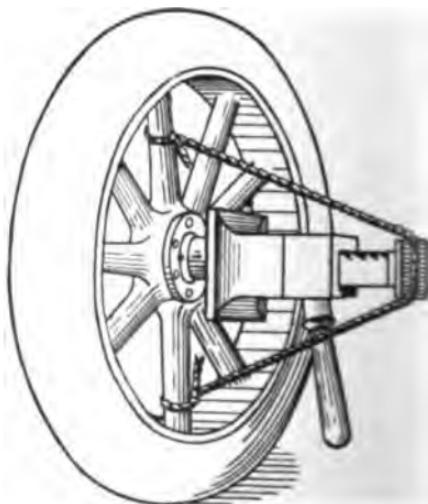


Fig. 63. Makeshift Wheel Puller for Road Repair Work

tire chains—particularly extra cross links—may be fastened together to answer the purpose. If chain is lacking, strong wire, wire cable, or in a pinch stout rope can be substituted. Attach the rope, wire, or chain to a pair of opposite spokes of the wheel, Fig. 63, allowing usually about two feet of slack. Draw the chain out as tightly as possible, place the jack with its base against the end of the axle and work the head out by means of the lever until it comes against the chain. Then by continued but careful working of the jack, the wheel is pulled off the axle.

If rope, wire, or wire cable is used, it is advisable to place a heavy piece of cloth, burlap, or something similar over the head of the jack to prevent its edges cutting through this material. With rope only enough slack must be used to allow the jack in its lowest position to be forced under it; this must be done because there is so much stretch to the rope itself and so little movement in the ordinary jack, that the combination of rope and jack does not always work to advantage.

Similarly, the handling of heavy truck wheels gives much trouble even in the garage, for they are so big, heavy, and bulky, that ordinarily two men are needed. One man can do the trick however, with a platform or "dolly" like that shown in

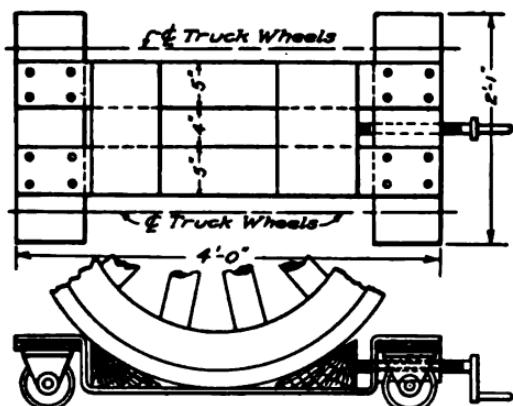


Fig. 64. Tire Platform or "Dolly" for Handling Truck Wheels

Fig. 64. This consists of a platform about four feet long by 25 inches wide, fitted with casters at the four corners. Inside of the central part are placed a pair of wedges, one of which can be moved in or out by means of a crank handle. To use this, the wheel is jacked up a little over two inches and the truck slid under. Then the movable wedge is forced in against the tire so that the two wedges hold the wheel firmly and carry all of its weight. Then the casters are turned at right angles so that the platform and the wheel may be moved off together. The truck wheel is removed in the usual manner. The dolly also helps in putting it back on its axle.

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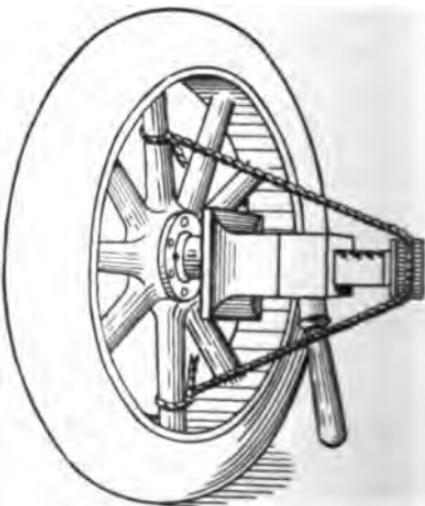


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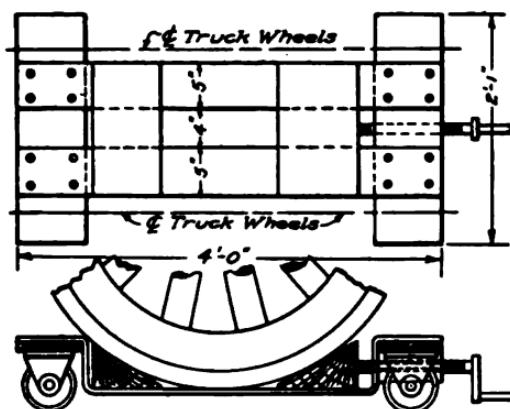


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DEMOUNTABLE RIMS

Standardization of Rim Types. In a comparatively few years the demountable rim in its various forms has displaced all of its competitors and made the lot of the automobile driver a far more pleasant one than used to be in the days of the less convenient forms of tire equipment. The *plain* rim which was first in the field is no longer used; the *clincher* type which was a very popular form is still used on some of the older types of cars but as a result of their convenience the demountable types are well-nigh universal on new cars.



Fig. 65. Putting on a Q. D. Tire.
The Start



Fig. 66. Putting on a Q. D. Tire.
Forcing Flange over Rim

It is not intended in the following section to give extensive instructions for the repair of demountable rims. They seldom get out of order on account of their simple construction and in case of accident, the rims as well as the wheels are usually so badly damaged that they would be beyond repair. An attempt has been made to give only a very brief historical development of demountable rims and then by a discussion of the principal types give a clearer idea of how these are manipulated and in what directions the process of standardization is going on. Demountables certainly reduce the motorist's tire troubles on the road to a minimum.

Quick-Detachable Tire Rims. It was this inherent difficulty of handling the clincher tire and rim which brought about the quick-

detachable tire. This did not differ from the clincher tire in the tire portion, the difference being in the rim, which has one curved portion made in removable form, with a locking ring outside of it or made integral with it. In some quick detachables the rim is expanded by a special tool and a spacing piece set into place, which holds the edge expanded. When this is done, the ring—for it is a simple ring with special ends—is held in place until released by the use of the special tool. On the end of the ring there are two little square lugs which project downward and have a hook shape. The one edge of the rim—made flat and straight on that side—has a slot with staggered, rectangular ends into which these lugs fit.

It requires force to spring the rings together so the lugs will go into the slots, but once in place, the natural springiness of the ring holds them firmly in place, holding the tire as well.



FIG. 67. Putting on a Q. D. Tire.
The Locking Ring

Figs. 65, 66, and 67 are given to show how this ring is put in place on a tire. Fig. 65 shows the beginning of the operation, and the instructions for the different steps will make them clear. Thus:

Always start with left end of the ring. Lock this in the rim as shown in Fig. 65, so that the end of the ring is flush with the slot provided for the second end. A dowel pin is provided to register the ring in the proper place. This must always be correctly centered or the ring cannot be applied. This done, the balance of the ring can be forced over the flange of the rim, as shown in Fig. 66, with the exception of the locking end. By means of the tool, the last locking end can be raised and forced over the rim *into the recess* provided for holding same in position preparatory to drawing the ends together, see Fig. 67, showing correct position of tool.

Then by entering the two points of the tool in the holes provided in the ring, the ends may be drawn together, as shown in Fig. 67, and with a slight additional leverage the ends of the rings can be made flush.

Before proceeding further, it should be stated that the object of the Q. D. rim is the quick removal of the tire, in order to allow a quick repair or substitution of the inner tube. On the other hand, the object of the demountable, remountable, removable, and other rims is the removal with the tire of the rim itself to allow the substitution of a new tire and rim, the tire being already inflated and

ready for use as soon as applied. The object of the removable wheel is the removal of the entire wheel with rim and tire in order to substitute a spare wheel with already inflated tire.

It might be thought that these methods called for the carrying of extra weight, but the amount added is actually very small, for by their use tire tools and pump are dispensed with and their weight saved.

Fig. 68 shows the former Goodyear rim. This, as will be noted, is of the Q. D. type, the idea being to remove the tire easily. The rim itself has a button-hook shape with a slight ridge or projection answering to the handle. This is on the fixed side, the inner flange inside of the tire butting against it as a stop. The tire is pushed over against this, being held on the outside by a second flange of similar shape. The latter, in turn, is fixed in place by a locking ring, a simple split circular ring of deep oval section. This fits it to the button-hook perfectly, its contour being such as to fit it exactly. In use, it is sprung into place, the outer edge of the hook on the rim and the natural spring of the tire preventing it from falling out. This makes a very simple and removable Q. D. rim. To make doubly certain that the locking ring can not jump out, a sprag-like plate is fastened to the valve stem; screwing this down it fits place wedges the head of the stem over against the valve flange, which in turn presses the lock ring tight against the curve out in part of the hooked rim. When in this locked position, the upper part of the flange hangs over the valve stem, so that it cannot be removed, the only manner in which it could come off. This rim is shown with a detachable tire, of course, but may be used with any standard clincher tire by the use of extra valve flanges. Fig. 69 shows the rim with a set of valve flanges in position, ready to take a standard clincher tire.



Fig. 68. Former Goodyear Removable Rim.

Q. D. Number 2. Figs. 70 and 71 show the standard Q. D. rim, now known as No. 2. This was adopted by the Association of Licensed Automobile Manufacturers as a standard and given the above name. It has the feature of accommodating all regular clincher or Dunlop tires. In Fig. 70 it is shown at *A* ready for a clincher tire and at *B* ready for a Dunlop tire, a solid rubber filling piece being used to fill up the deep groove in the clincher rim shape on the inside, while

the flange is turned over on the outside, the contour of the outer portion being such as to correspond exactly to the exterior of Dunlop tires.



Fig. 70. Arranging Goodyear Rim in Clincher Tire

making clear the exact use of this reversible flange. *A* shows a regular clincher tire in place, while *B* reveals the reversed flange in place with a Dunlop tire. Both Fig. 70 and Fig. 71 show the construction of the device, the outer dropped portion of the rim having a hole through it. The locking ring is split vertically and one end, just at the split, carries a projection or dowel pin extending downward. To put the rim on, this dowel pin must be fitted into the hole in the rim to give

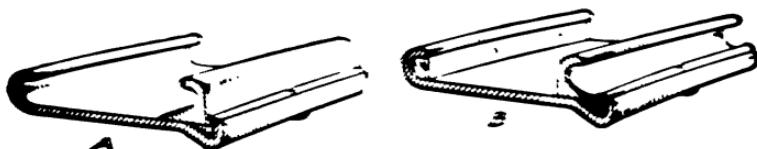


Fig. 71. Universal Q. D. Rim No. 2 Arranged for Clincher and Dunlop Tire

a starting place. When this has been done, one may slide the balance of the ring into place around the wheel with any suitable thin, wedge-shaped tool.

The shape of this locking ring with a right-angled groove in its inner edge permits the outer flange to overlap it, which insures the retention of the rim, when once it has been put in place. Furthermore it gives the outer side flange a wider seat on the tire, thus making it more stable and longer wearing.

As will be noted, the difference between these two rims—that is, the old Goodyear and the Universal No. 2—is in the saving of one

turn being held by means of local wedges. Any of the plain demountables, which will be called demountables from now on, may be of

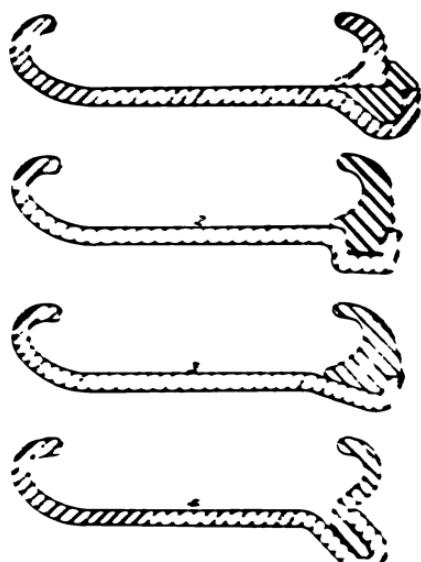


FIG. 74. Popular Forms of Q.D. Clincher Rims, Shown in Sections

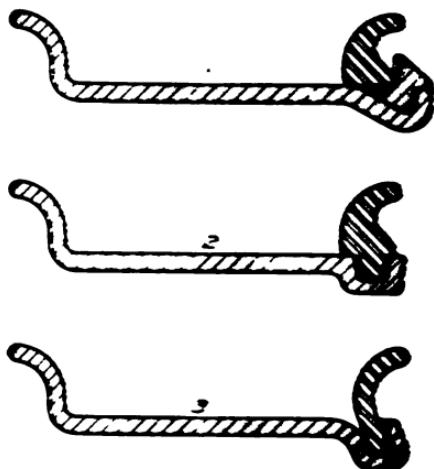


FIG. 75. Three of the Most Widely Used Straight-Side Q.D. Rims

either type of attachment, as is also the case with the first-named or demountable-detachables.

Local-Wedge Type. In the so-called local-wedge type which includes the well known Continental forms notably Standard Universal Demountable No. 3 and Stanweld Nos. 22 and 30.

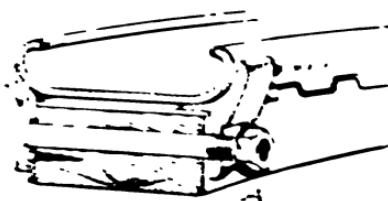


FIG. 76. Michelin and Empire Demountable Rims

Michelin, Empire, Baker, Detroit, Prudden, Standard Universal Demountables Nos. 1 (formerly the Marsh) and 2, and others, loosening the six (or eight, as the case may be) bolts frees the rim

Q. D. Number 2. Figs. 70 and 71 show the standard Q. D. rim, now known as No. 2. This was adopted by the Association of Licensed Automobile Manufacturers as a standard and given the above name. It has the feature of accommodating all regular clincher or Dunlop tires. In Fig. 70 it is shown at *A* ready for a clincher tire and at *B* ready for a Dunlop tire, a solid rubber filling piece being used to fill up the deep groove in the clincher rim shape on the inside, while



Fig. 69. Adapting Goodyear Rim to Clincher Tires

the flange is turned over on the outside, the contour of the outer portion being such as to correspond exactly to the exterior of Dunlop tires.

The two parts of Fig. 71 show sections of tires in place,

making clear the exact use of this reversible flange. *A* shows a regular clincher tire in place, while *B* reveals the reversed flange in place with a Dunlop tire. Both Fig. 70 and Fig. 71 show the construction of the device, the outer dropped portion of the rim having a hole through it. The locking ring is split vertically and one end, just at the split, carries a projection or dowel pin extending downward. To put the rim on, this dowel pin must be fitted into the hole in the rim to give

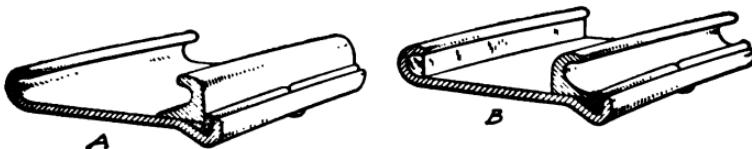


Fig. 70. Universal Q. D. Rim No. 2 Arranged for Clincher and Dunlop Tires

a starting place. When this has been done, one may force the balance of the ring into place around the wheel with any suitable, thin, wedge-shaped tool.

The shape of this locking ring with a right-angled groove in its inner edge permits the outer flange to overlap it, which insures the retention of the ring, when once it has been put in place. Furthermore it gives the outer side flange a wider seat on the rim, thus making it more stable and longer wearing.

As will be noted, the difference between these two rims—that is, the old Goodyear and the Universal No. 2—lies in the saving of one

ring and the shape of the locking ring. Both of these are called universal rims because they may be used interchangeably for straight-side and clincher types of tire. Other Q. D. Universals are shown in Fig. 72, although, in the opinion of tire men, the Universal form is slowly going out of use.

To explain these briefly, No. 1 is a modification of the Goodyear with different shaped inner rings, while the locking ring and the lip formed in the felloe band to receive it are similar to those of Universal No. 2. In 2 the only difference from 1 lies in the locking ring, which has a modified Z section, with a lip extending over the outer edge of the felloe band. The third section differs from the other two only in having the outer ring and locking ring combined into one, and the felloe band changed to suit this. This combination ring is held in place by means of a simple swinging latch, which is shown open and

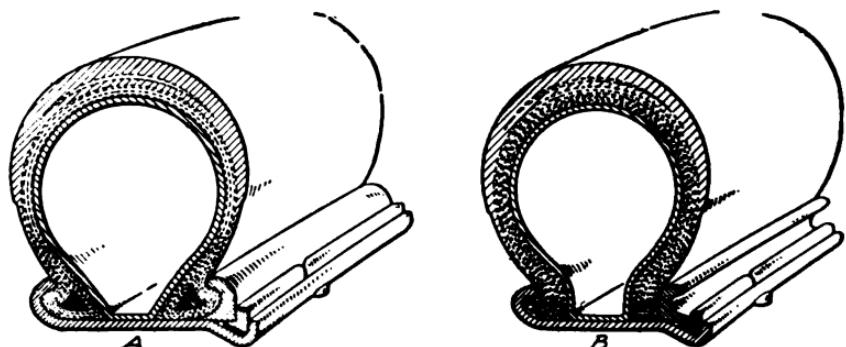


Fig. 71. Universal Q. D. Rim with Tires in Place

closed in Fig. 73. When opened, this permits raising the end of the ring, to which the shape of the felloe band offers no resistance. The whole inner ring is taken off, following around the circumference of the wheel, after which the tire is easily removed.

Q. D. Clincher Forms. To return to the plain clincher tire and the Q. D. rim, which allows of its ready removal, Fig. 74 shows four of the most prominent forms, these being indicated simply as flat sections of the rim, for the tire is the same in all cases. All these have the simple clincher edge on one side, with removable ring and locking device on the other. That at 1 has the same locking device shown at 2 in Fig. 72, the Z-shaped ring extending over the edge of the band. That at 2 is practically the same as 3 in Fig. 72. The one seen at 3

is similar to that at 2 except for the detailed shape of the ring as well as of the lock, not shown. The advantage of the form shown at 4 is that the outer ring is self-locking, that is, the shape of ring and band are such that when the former is in place, the tire itself locks it. Its only disadvantage is that it is harder to operate than the other forms,

yet despite this fact it has been recommended for general adoption as the only type of Q.D. clincher rim worth continuing.

Q.D. Type for Straight Sides.

To close the subject of straight side tires, the rims of the quick-detachable form now in use aside from those already shown are seen in Fig. 75. Here these are seen to be identical with 1, 2, and 4 of Fig. 74, except that the fixed side is arranged for a straight side instead of being

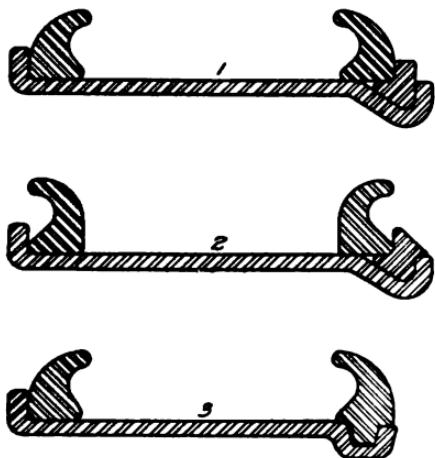


Fig. 72. Sections through Three Popular Q.D. Universal Rims

made with a clinch. Here again, the last form of self-locking type has been recommended as a standard.

Demountable Rims. All, or practically all, demountable rims come under one of two headings—those in which the tire can be

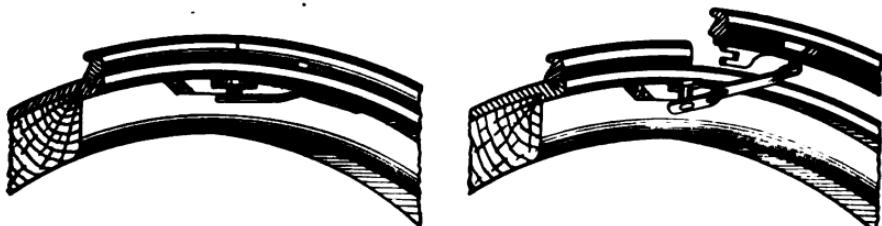


Fig. 73. Latch Used for Locking Single Combination Ring which Replaces Former Side Ring and Locking Ring

detached on the wheel without demounting (if it is so desired), and those which are of the transversely split type and must be demounted before the tire can be removed. In addition, there is a second division of demountable rims into those which have a local-wedge form of attachment and those which have a continuous holding ring, this in

turn being held by means of local wedges. Any of the plain demountables, which will be called demountables from now on, may be of

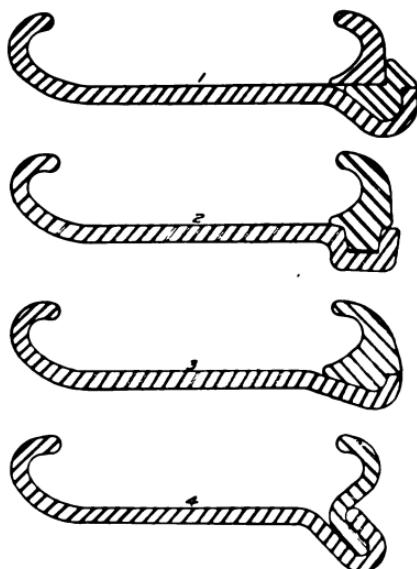


Fig. 74. Popular Forms of Q.D. Clincher Rims, Shown in Sections

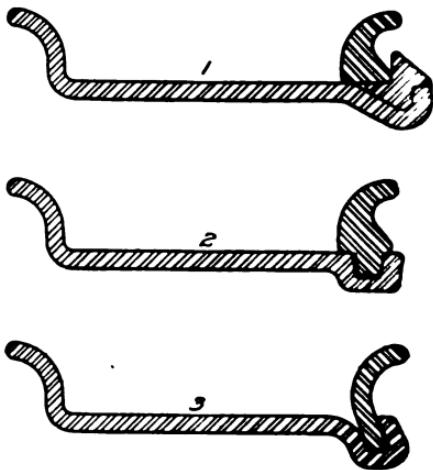


Fig. 75. Three of the Most Widely Used Straight Sine Q.D. Rims

either type of attachment, as is also the case with the first-named or demountable-detachables.

Local-Wedge Type. In the so-called local-wedge type which includes the well known Continental forms (notably Standard Universal Demountable No. 3 and Stanweld Nos. 22 and 30),

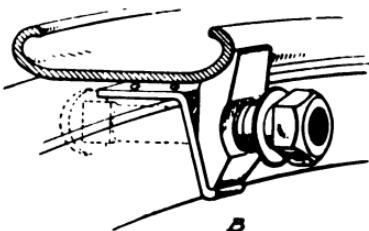
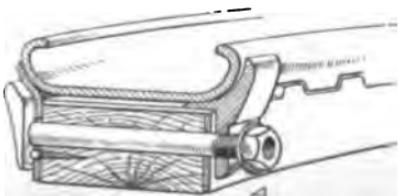


Fig. 76. Sections of Michelin and Empire Demountable Rims

Michelin, Empire, Baker, Detroit, Prudden, Standard Universal Demountables Nos. 1 (formerly the Marsh) and 2, and others, loosening the six (or eight, as the case may be) bolts frees the rim

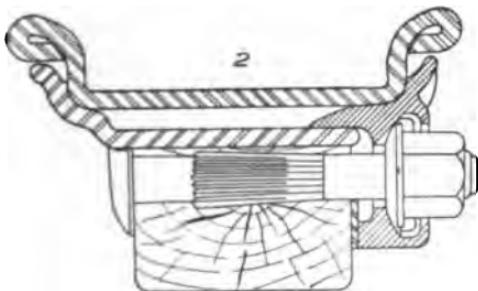
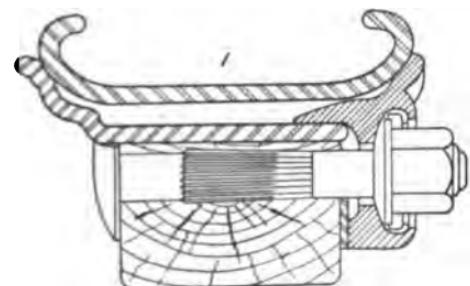


Fig. 77. Two Popular Demountable Rim Forms—
of Clincher Tires Above, for Straight-Side Below

loosened, because of its heavier weight and the fact that there is no projecting edge to prevent it. While this latter construction makes

directly without further work. In some of these, such as the Michelin, the various Continentals, including Stanweld 22 and 30, Detroit, Baker, and others, the wedges carry a projecting lip, which makes it necessary to unscrew the nuts far enough to allow the removal of the wedge so as to pick this lip out from under the tire-carrying rim. In others, such as Empire, S. U. Nos. 1 and 2, the construction of the wedge and rim is such that loosening them frees the rim, the upper part of the wedge or clip swinging down to the bottom position as soon as

In Fig. 77 is shown a pair of additional demountables, which are held by the local-wedge method, the difference here being in the form of wedge. Note that 1 has a solid clincher rim and 2 a straight side rim. The base, however, is the same for both and, as

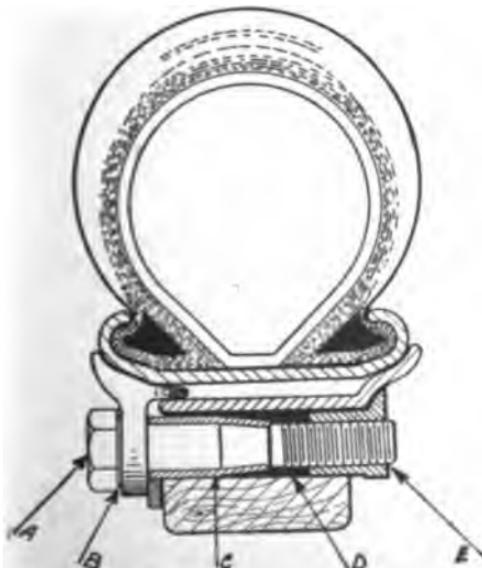


Fig. 78. Sectional Drawing Showing Con-
struction of Baker Demountable Rim

will be seen by examining this, has two curves in its upper surface, the straight side rim fitting into the lower or bottom one, while the clincher form of rim fits into the upper one. Note, also, that the wedges are the same for these two. This makes the demountable parts of the rim practically universal, in that the owner can change from clincher to straight side or *vice versa* by simply purchasing the extra set of tire-carrying rims, no change in the wheels or means of attachment being necessary. For this reason, the felloe band shown under these two rims has been suggested as a standard for demountable.

Process of Changing Baker Local-Wedge Type. In Fig. 78 is shown the Baker, which, as mentioned previously, is of the local wedge type of demountable, having a transversely split rim which must be removed from the wheel before the tire can be taken off of it. Perhaps this whole action will be shown more clearly by the progressive series of views, Figs. 79 to 89, which show the various steps in removing and replacing a tire and tube mounted on a Baker rim, the same as is shown in section in Fig. 77. First, all the we-



Fig. 79. The First Operation in Removing Baker Demountable—Loosening the Bolts



Fig. 80. Second Baker Demounting Operation—Jacking the Wheel and Starting to Pry off Rim



Fig. 83. Fifth Operation—Starting to Take the Rim out of the Tire—Beginning to Pry Short End



Fig. 84. Sixth Operation—Forcing Down the Short End of Rim



Fig. 85. Seventh Operation—Prying under the Loose End of Rim



Fig. 86. Eighth Operation—Raising the Free End of Rim, Using Both Hands



Fig. 87. Ninth Operation—Inserting Valve Stem and Beads in End of Rim



Fig. 88. Tenth Operation—Prying Tire Away from Rim to Let latter Slip into Place

the extreme end has been freed in this way, the operation is repeated some 5 or 6 inches farther around, that is, that much farther away from the slit. This done, a considerable portion of one end will be free. Then turn the rim and tire over so that this free part comes at the top instead of at the bottom and, standing on the part which is still tight, insert the tire tool beneath the rim and between it and the entire tire.

This frees the entire end, but, to make sure, the tool must be slid along a little farther so as to free more of it. When enough has been freed to allow grasping it with both hands, as shown in Fig. 86, the tool is dispensed with and, taking a firm grip on the rim, at the same time standing on the tire at the point where tire and rim still contact, pull upward strongly. When followed all the way around this pulls the rim entirely out of the tire.

Having the casing and tube free, they may now be inspected and repaired. When this is done, or if it is not done and a new tire or tube or both are used, the worker is ready now to replace the rim. This is practically the reverse of the method just followed out. As shown in Fig. 87, the rim is laid on the floor; then the end is raised which has the valve-stem hole drilled in it and the valve stem inserted. Next the beads are pulled into the rim, it being necessary to press them together somewhat tightly in order to do this, but with a little practice it soon becomes an easy matter. All this is done with the other part of the rim, the free end, which is inserted last and removed first, underneath the tire.

The inserted end of the rim is followed around with the thin end of the tire tool, as shown in Fig. 88, the position of the tire above the rim allowing the workman to stand on it and thus use his weight to press the two sides of the tire together and, at the same time, to force them into the rim. This operation is followed right around the inside circumference of the tire, the free or short end of the rim being the last part to enter. On account of the shape of the joint or cut in it, this should slip readily into its proper place, but if it does not, the thin end of the tool can be used to pry it into place, or a hammer can be used on the longer side in order to drive it in.

Lastly, the rim being fitted snugly into place all around, the anchor plate is inserted to prevent the short end slipping out again, and the tire is ready for inflation. If it is to be carried as a spare, the

dust cap should be screwed into place over the valve stem, so as to preserve the threads which may be damaged in handling if they are not covered.

Rim with Straight Split. This covers the action of practically all the demountables in which the transversely split rim is used, necessitating the removal of the rim and tire from the wheel before the tire can be taken off the rim.

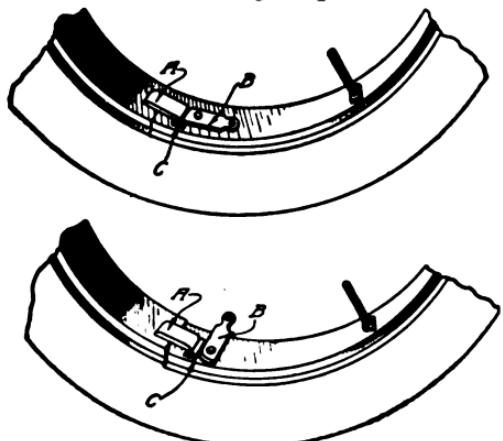


Fig. 90. One-Piece Rim, Showing Right-Angled Split and Locking Device
Courtesy of Standard Welding Company, Cleveland, Ohio

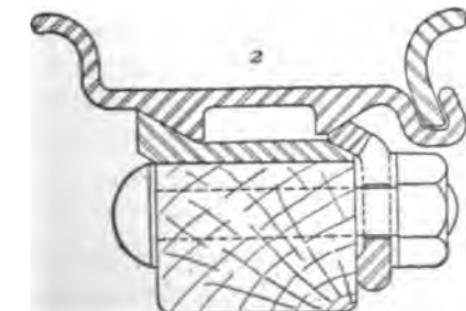
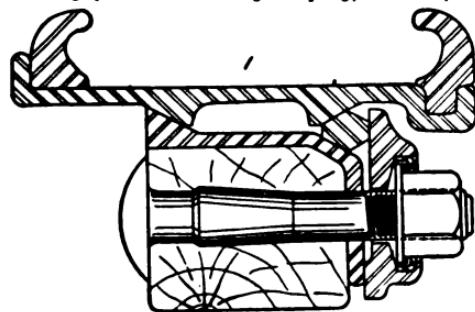


Fig. 91. Sections through Two Popular Forms of Demountable-Detachable Rims

C, which holds the two ends together, can be opened by lifting the tire with this portion at the bottom and then dropping it a couple



of times. This done—and usually this action will be accompanied by the free end springing inside the fixed end—continuation of the removal is an easy matter. The rim shown is the Stanweld 20.

Comparison of Continuous Holding Ring Type with Local-Wedge Type. To return to demountable-detachable rims, these may and do include a number of those quick-detachable forms previously shown and described. In Fig. 91 a pair of typical forms is shown, that at 1 being fitted for a clincher tire, while that at 2 is for a straight side. Looking at the detachable part of the rim, number 1 will be recognized as that previously shown at 3, Fig. 72, where it was described as a universal rim, the inversion of the two rings converting it from a clincher to a straight side, or *vice versa*. Similarly, 2 will be recognized as the form of detachable shown at 3 in Fig. 75.

Here, however, both are fitted to be used as demountables, this being accomplished by the formation on the under side of the band of a pair of wedge-shaped projections. The felloe band is so made and applied that it forms one surface to contact with one of these wedges, while the other is formed variously. At 1, a separate ring is used with the flat outside clips to hold this against both felloe band and rim, while at 2, the wedges or clips have an extension which presses against the outer wedge on the rim. This latter distinction divides these two into the two classes mentioned previously, 1 into the continuous holding-ring class, the other into the local-wedge type.

These forms are shown to illustrate this point and also because despite this difference they have practically similar felloe bands. This felloe band—that is, of the form shown in 2—has been recommended as a standard for all demountable-detachable rims. Another and different example of the clamping-ring demountable-detachable type is shown in Fig. 92, this being the Firestone rim. Here it will be

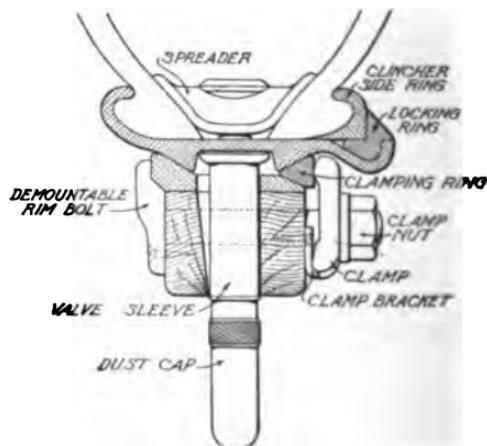


Fig. 92. Section of Tire and Rim of Firestone Demountable Tire

noted is the felloe band just mentioned, while the detachable-rim portion is that previously shown at 1 in Fig. 74 as having the Z-shaped locking ring and being adapted to clincher tires only. In this instance, the rim band is made with the two wedge-shaped projections on its underside to allow for the addition of the demountable feature.

Perlman Rim Patents. Late in the summer of 1915, considerable consternation was caused among tire and rim manufacturers when it became known that the Perlman rim patent had been adjudged basic by the courts, and that, on the strength of this decision, an injunction had been issued against the Standard Welding Company, of Cleveland, Ohio, some few of whose rims have been previously described. Perlman's original patent was applied for on June 29, 1906, and in addition to this record the fact was established that the owner had a Welch car which had traveled over 150,000 miles and on which were a set of the original rims. The case dragged through the courts and was discontinued some seven or eight years ago. Perlman persisted, however, although he had to revise and alter his application many times; the basic patents were finally allowed, and issued to him in February, 1913. This means, of course, that the patent will not expire until the year 1930.

His locking elements and the principle involved are shown in Fig. 93, which is a section through the rim and felloe. In Perlman's suit it was claimed that the wedge end of the bolt which was covered in his patent, included all wedge operating rims, whether actuated from the center, as in Fig. 93, or from the side. This contention was supported by the court and negotiations are now in process between Perlman and many manufacturers of the so-called local wedge type of rim. As this would appear to cover all the rims shown and described by Figs. 76 to 92, inclusive, the influence of this decision upon the industry can be imagined. Moreover, the length of time which this basic patent has to run precludes the possi-

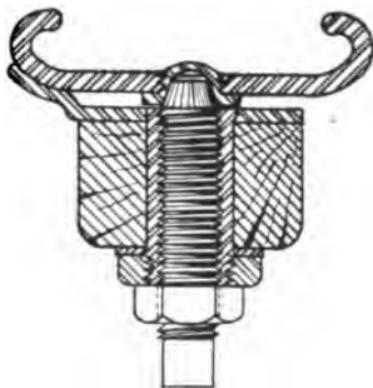


Fig. 93. Section of Perlman Rim, Showing Locking Device

bility of delaying action by prolongation of suits, as has been done in similar cases. A notable example of this is the case of the Selden automobile patents which were fought on one ground or another over a long period of years.

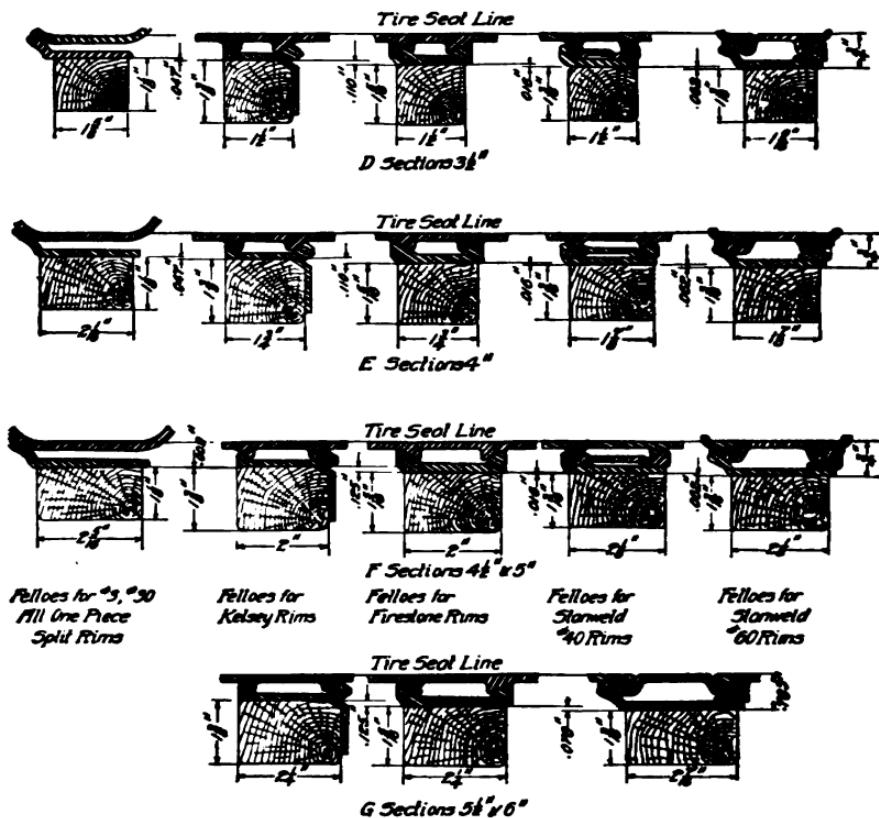


Fig. 94. Typical Felloe, Band, and Rim Sections for Popular Demountable Rims

Standard Sizes of Tires and Rims. As might have been noted in going over the above discussion of tires, plain rims, detachable rims, and finally, demountable rims, all these different constructions require widely differing wheel sizes. It has been proposed to standardize wheels—that is, the outside diameter of the felloe, and with it the thickness of felloe bands as well as their shapes or contours, one for each tire cross section. With the proposed reduction of tire sizes to nine standards as follows: 30 by 3, 30 by $3\frac{1}{2}$, 32 by $3\frac{1}{2}$, 32 by 4, 34 by $4\frac{1}{2}$, 36 by $4\frac{1}{2}$, 38 by $5\frac{1}{2}$ and probably 36 by 5, supplying these sizes and these only to manufacturers of cars, but making additional

oversizes for car users, one for each size above, that is 31 by $3\frac{1}{2}$ for 30 by 3, 31 by 4 for 30 by $3\frac{1}{2}$, 33 by 4 for 32 by $3\frac{1}{2}$, 33 by $4\frac{1}{2}$ for 32 by 4, 35 by $4\frac{1}{2}$ for 34 by 4, 35 by 5 for 34 by $4\frac{1}{2}$, 37 by 5 for 36 by $4\frac{1}{2}$, 39 by 6 for 38 by $5\frac{1}{2}$ and probably 37 by $5\frac{1}{2}$ for the 36 by 5, rim standardization will soon follow the adoption of these sizes. In this event, in the course of time will come the standardization of demountable rims.

At the present, there is a wide range of difference, as will be noted in the drawing Fig. 94, which shows felloes for the most widely used demountable rims, depicting the band and rim in each case. The drawing should be read crosswise, each horizontal line showing the differences to be found in the makes mentioned in that particular tire-cross-section size. Thus, the *D* sections show the differences for $3\frac{1}{2}$ -inch tires, *E* those for 4-inch tires, *F* those for $4\frac{1}{2}$ - and 5-inch tires, and *G* those for $5\frac{1}{2}$ - and 6-inch tires, rims for which are not produced by all makers.

Other Removable Forms. Outside of the regular range of wood wheels and the standard tires for them, any different wheel calls for a different treatment. As has already been mentioned under the subject of wire wheels, few of these have anything but a solid one-piece clincher rim, first, because the wheel itself is removable, thus making it as easy to change wheels as to change rims in the ordinary case, and second, to save weight and complication.

Demountable for Wire Wheels. However, demountable forms have been produced for wire wheels, one being shown in Figs. 95 and 96. This is the G-R-C double Q.D. rim as the makers prefer to call it, in action a demountable-detachable form, the clincher rim being of the straight-split type, in fact, a Stanweld 20. This is made with a double wedging surface on the outside and a single one on the inside. The latter contacts with another on the false rim to which the wire spokes are attached, as does also the inner wedging surface on the outer wedge. The outer wedging surface is made so as to come just above a fairly deep slot in the false rim. In this is placed a ring with a double wedge-shaped upper edge and a square lower edge. This ring is split at one point and locked in the highest position at the point diametrically opposite.

At the split point a pair of bent-arm levers, Fig. 95, are connected at the two ends. Attached to a middle point of each of

these is one end of an inverted U-shaped member, the center and upper part of which form a bearing for a locking stud, which is attached to one end of the ring.

Above this is placed a nut. As will be noted, this forms a toggle motion, the action of which is to expand the whole ring when the nut is screwed down, and to contract it when the nut is screwed up.

This is the precise action used, the single ring forming the whole locking means, and being actuated by the toggle mechanism through the medium of screwing the nut up or down. While at its best on wire wheels because of its simplicity, this rim is, of course, applicable to wood wheels. At present, its makers are specializing on the wirewheel forms.

Parker Rim-Locking Device. Another rim-locking device which does not come under any of the standard divisions, being devised for use on the Parker Hydraulic wheel, is the Parker modification of the former Healy rim. As shown in Fig. 97, which shows the end of a steel spoke in section, this is made with a cup at the upper and inner end, while at the outer is a loose clip, through which passes a bolt with a head on the outside. Tightening the bolt by means of the external head draws the clip up the incline



Fig. 95. Operating Device on the Ashley Moyer Double Q.D. Rim for Wire Wheels

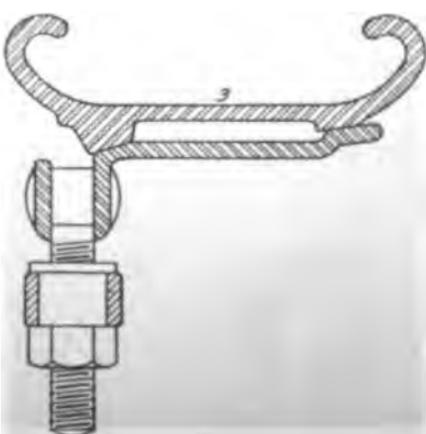
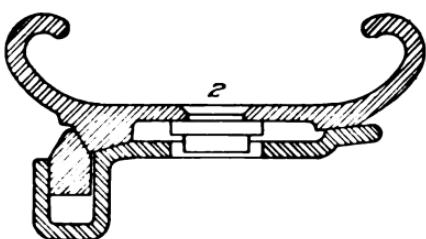
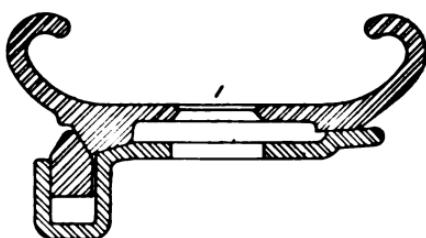


Fig. 96. Section through Rim and Band of G-R-C Rim Showing Wedging Band and Its Operation

at the bottom of the cup, against the wedge on the underside of the rim, the amount of pressure exerted depending solely upon that applied to the bolthead. As the two wedge shapes oppose one another, this holds the rim as firmly as is possible. It will be noted that this construction does away altogether with the use of felloe bands or false rims used on other forms of rims or wheels, thus saving much weight. Moreover, a great part of the weight is saved at the outside, where the flywheel effect of rapid rotation is thus lessened. Moreover, the absence of additional metal here would give the tire more chance to radiate its heat, and thus would preserve it better. This construction, considering its many advantages, should have a wide use.

Similarly, with all demountable rims, the tendency is toward wider and wider use, with which comes lower and lower cost, as well as a better and wider understanding of their use, abuse, attachment, and detachment. With the standardization of tires to a few standard sizes, say 9 instead of 54, it will be only a few years before all kinds of rims including demountables will be standardized, at which time the latter will come into universal use.

TIRE CONSTRUCTION AND REPAIR

Before concluding these remarks on the general subject of small overhaul and repair work, it will be well to say something on the subject of tires. These are at the same time the most delicate, the most misunderstood, and the hardest working parts of a car. They are delicate because the materials comprising them are soft, pliable, and very easily damaged, as compared with the various selected metals entering into a car's makeup. They are misunderstood for various reasons, and in many different ways; composition utility of and necessity for the various components, proper and



Fig. 97. Construction of Parker Hydraulic Steel Wheel Spokes, and Operation of Locking Device for Rims

improper methods of use, correct and incorrect inflation pressures, troubles and remedies, and other things, come under this category.

Composition and Manufacture. Tires consist of two parts, the tube and the shoe or casing. The former is a plain ring of circular cross-section, made of pure rubber, containing an air valve, and is

intended only to hold the air. The shoe or casing, on the other hand, provides the wearing surface, protects the air container within from all road and other injuries, and constitutes or incorporates the method of fastening itself to the wheel. In its construction are included the fabric—preferably cotton—some pure rubber, and much rubber composition, the whole baked into a complete unit by heat and in the presence of sulphur, which acts somewhat as a flux for rubber.

Considering a typical tire, Fig. 98, there enters into its makeup, starting from the inside, six or seven strips of frictioned fabric—that is, thin sheets of pure gum rubber rolled into intimate contact with each side of the cotton, making it really a rubber-coated material. Next, there is the so-called padding which is more or less pure rubber, has a maximum thickness at the

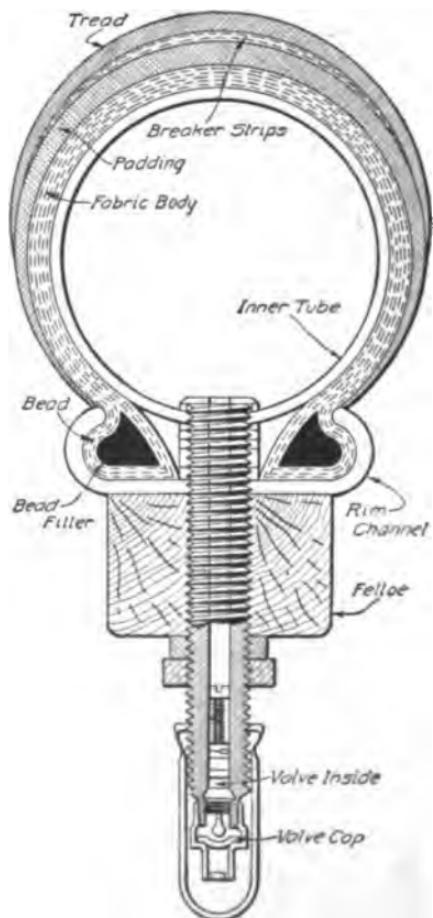


Fig. 98. Section through Assembled Tire and Tube, Showing Construction and Parts of the Tire and Tire Valve

center of the tread, and tapers off to nothing at the sides, but usually carrying down to the beading. Above this, there is placed a breaker strip, consisting of two or three layers of frictioned fabric impregnated in a rubber composition. This, too, is thickest at the center and tapers off to the sides, but ends at the edge of the tread. Finally, there is the surface covering, called by rubber men *the tread*;

this contains very little pure rubber, being thickest at the center and extending with decreased thickness almost down to the bead.

The last two of this series of layers constitute the real wearing surface of the tire, and when the surface is so worn that the breaker strip may be seen, it is time to have the tire retreaded. When the wear has gone through this, if the padding be fairly complete, retreading will still save the tire, but if wear has gone deep enough to expose the fabric, the shoe must be run to a finish and then discarded.

All this construction can be noted in Fig. 98, which shows a section through a tire, with the inner tube in place, the section being taken so as to pass through the center of the tire valve. This should be borne in mind when examining this figure, for the location of the inner tube inside the tire is likely to be misleading.

Cord Tires. The real improvement of value, however, is the cord tire. One form of this is shown in partial section in Fig. 99. This shows graphically that the difference between this tire and other forms is that the 4 to 6 or more layers of fabric have been replaced by two layers of diagonally woven cord. This cord is continuous, rubber impregnated, rubber covered, and through its

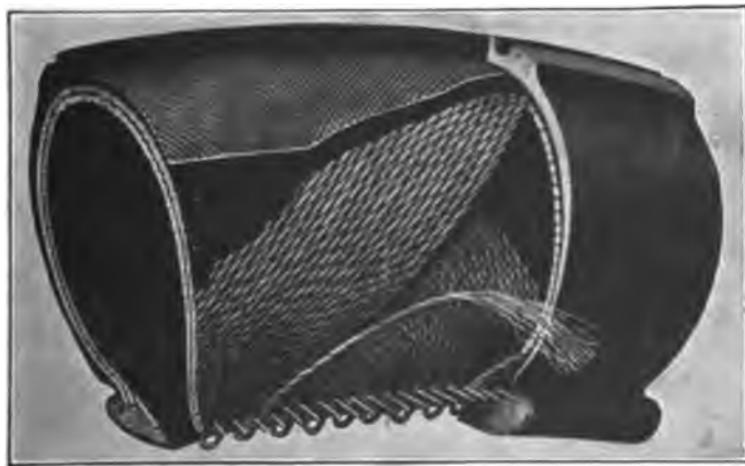


Fig. 99. Section of Goodrich Silvertown Cord Tire, Showing Inner Construction

size, allows a great and very even tension. Lessening the amount and thickness of the fabric has given a greater percentage of rubber in the tire, consequently, the cord tire is more resilient. The advantages claimed for it are: Less power used in tire friction, which means

more power available for speed and hill climbing; greater carrying capacity in same size; saving of fuel; greater mileage per gallon of fuel; additional speed; quicker starting; easier steering and, therefore, less driving fatigue; greater coasting ability; increased strength; and practical immunity from stone bruises because of their superior resiliency.

Bead. In the mention of tire construction above, moreover, no mention has been made of the bead. This is a highly important part of the tire, for it is the part which holds it in place on the wheel. It is made of a fairly hard rubber composition, the fabric being carried down on the sides so as to cover it. In a cross-section, it has a shape very close to an equilateral triangle resting on its base; around the wheel it is curved to fit the rim. The method of attaching the tire has a considerable influence on bead construction, for in the clincher type of tire, in which the shoe must be stretched on over the rim, the bead must be extensible in order to insure easy mounting. In the quick-detachable and straight side forms of tire, however, there is no need for this excessive stretching, so that the bead can be made of much stiffer and more rigid material as well as cut down somewhat in size.

The straight side or Dunlop type of tire is seldom made with much of any bead, the layers of fabric being carried straight down. A more modern form of tire has a pair of woven-wire cables incorporated in the bead to make it stiffer and stronger, and this is said to have been very successful. As has been pointed out previously, this could be done only with the quick-detachable form, not with the clincher type.

In both the clincher and the quick-detachable forms, the bead holds the tire to the wheel by means of certain parts of the rim, which bear on it from above, as well as sideways, the internal pressure of the air when the tire is inflated pressing it against these parts very firmly.

General Repair Work. Bead and Tread in Old Tires. It is often found that the bead of one tire is damaged; in this case the tire is useless except in one of the reconstruction processes by which one old and partly damaged tire is selected for its good bead and lower part while another old and partly worn-out tire with a poor bead is selected for its good tread portion.

The bead is then cut off the latter, the edge at this point being cut down so as to be as thin as possible, and the latter tire sewed on the top of the former. The good bead of the former serves as the bead for the combination, while the double thickness of tread, even if both were worn somewhat, gives a long life. As doubling up the tread portion doubles up the number of layers of frictioned fabric, which is difficult to piece, this combination results in a tire which is almost puncture-proof. Of course, the combination is not a handsome tire, such as a new one would be, but considering that it is made from two old tires which were ready to be discarded, and that too, at an expense of less than seven dollars, and that it will give a mileage approximately equal to a new tire, one should not mind the looks.

Punctures. A puncture ordinarily penetrates the outer casing, and punctures the tube. When the latter has been patched, the whole tire is apparently as good as new. In reality, it is far from that, for the patch on the tube will never be as strong as the original while the hole through the shoe may or may not be the cause of a subsequent blow-out or other severe trouble. If the rubber composition is at all torn, this should be taken to a repair man for a small insert of patching rubber, and vulcanization. This makes the shoe practically as good as new, for the vulcanizing operation incorporates the small patch into the tire as firmly as any other part of it.

If not vulcanized, a small pebble may lodge in this little hole, and through the pressure of the car upon it and road shocks and blows, may be driven gradually inward, opening up the hole as it goes, until other and larger stones are picked up, driven in, and the work of destruction continued. This goes on if the owner does not notice and fix it, until the material above the air tube, pumped up to perhaps 75 or 80 pounds pressure per square inch, becomes too thin and weak to support it longer, when a small explosion takes place, the air bursting through the envelope. This is technically known as a blow-out, and if severe or far reaching, may put the valuable casing beyond the reach of repairs.

Not all blow-outs are caused in this way, many occurring on the side of the tire where a fault develops, which is enlarged by a blow or cut, until the material can stand the internal pressure no longer. When the car is run continuously in car tracks, or in the

deep ruts of a country road, the thin sides of the tire chafe off very rapidly; the rubber on the side is purer and cuts more easily.

Whenever the surface of a tire, comparatively new and thus worth looking after, is injured, it is well to repair this at once.

While neither this treatment nor anything else will make an old tire new, it will help greatly in keeping a new tire new and in the best of condition, it will keep the tire repair bills down to a minimum, and it will decrease greatly the tire cost per mile, and in these and other ways contribute much to the pleasure of motoring.



Fig. 100.
Sand Blister

Sand Blister. A tire trouble with which everyone should be familiar, because it happens frequently, is that known as a sand blister. This consists of a small round bump which appears usually at one side of the tire, Fig. 100. It may or may not protrude from the tire some distance, depending upon its size and location. When felt of, it will be found to be very hard. This is no more or less than a cluster of sand or dirt particles which have entered the tire at some small hole close by and have worked under the tread to the side. Whenever a sand blister is found, a small hole in the tread will also be found close by.

The way to fix this is to open the bump, take out all the dirt therein—you will be surprised at the amount of it, when you open your first one—then close up the opening through which the dirt came. To do this, proceed as follows: Get over on the side where the bump projects and, reaching around under it with a small and thin but sharp-pointed knife, cut a small hole into it from below. Remember, cut *from below*, for if cut from above the cut will remain and will itself gather in dirt. A cut made from below, however, will be closed partly by the compression of the rubber and will not gather any dirt in that position even if it does not close. Now with the point of the knife poke around in the hole so as to get out all dirt that will not run out when the first cut is made. By poking away at it for a while with the knife, then later, as it gets more nearly empty, with a match or similar small piece of wood, all of the dirt can be removed. The next thing to do is to fill up the hole in

the tread and if possible, the passage inside the tread to the blister. This is done by means of specially prepared rubber solutions, known variously as mastic, plastic, tire fillers, etc.

Tire Fillers. Tire fillers are supposed to consist of a solution of pure rubber in some solvent which will evaporate so that as soon as this substance is exposed to the air, it begins to harden and assume the form of pure rubber. The idea is that in liquid or semi-liquid form, this material can be forced into small holes, cuts, etc., which could not readily be filled up in any other way. At any rate, these tire fillers are very handy, and every owner should watch for small surface cuts and fill them promptly with something of this kind. If this preparation fulfills no other purpose, it prevents moisture and foreign materials from getting in and making the opening larger and larger. With a twenty-five cent tube of filler used early and often, a man can save himself a whole lot of trouble and several three-dollar and four-dollar repairs on his casings, as well as saving tubes.

Loosened Ridgy Tread. When the tread of the tire gets into a flat, out-of-shape condition, with waves along its surface, Fig. 101, the ridges feeling loose when touched with the fingers, this is a sign that the whole rubber portion of the tread has become loosened from the fabric below it. (See the tire section, Fig. 98.) This condition is brought about by continued running with insufficient air in the tire, that is, the driver is responsible for it, and the cause is under-inflation. At the same time, the tire which has been run any distance or for any length of time without enough air will show rim cutting, usually.

To explain the effect of under-inflation, suppose the weight of the car rests upon the poorly inflated tire and has flattened it out so that the car is running on the rubber rather than on the air within it. In this flattened condition, none of the parts of the tire can assume the shape and position intended. In the case of the tread, this is a different composition from the fabric beneath it and is united to the latter. In the flattened condition, the weight pressing down the sides of the tire has broken the bond between



Fig. 101.
Loosened Tread

the tread and the canvas at the center. Being loose all around the circumference at the center, this has assumed the wavy appearance noted; while continued running after this loosening began has doubtless loosened the tread clear over to the sides, in fact, all over. The remedy is a new tread, providing there are no further injuries to make this unwise; providing particularly there is no rim cutting; and providing that the tire was near enough to new to warrant such work and expense. Retreading is an expert tire man's job, and not for the novice or the amateur.

Rim Cutting. The second result of running with insufficient air pressure in the tires is rim cutting. By this is meant cutting through the sides of the tire with the edges of the rim. At sight, the latter seem to be rounded off and smooth, and such is the case; but by running with the weight of the car pressing them into the light sides of the tire where there is the least material, it does not take long to abrade the fabric, then cut it through, after which the moisture which gets in and continued running make short work of the tire.

This condition can be told at any time by examining the sides of the tire. If there is any sign of cutting or abrasion between the bead and the extreme edge of the tread, this may be considered a rim cutting, providing it is continuous around the tire and not restricted to one or two small spots. Referring again to Fig. 96, it will be noticed that on the lower part of the sides where the padding is tapering down to nothing and beyond the point where the tread has tapered to nothing and stopped, there is but the thicknesses of fabric to hold the tire together. That is, at this, the weakest point in the tire because there is the least need for strength here. The entire construction consists of some five or six layers of fabric with just a coating of rubber formed by the tapering end of the padding. It is at this point that the rim cutting is to be found.

A tire that is badly rim cut cannot be repaired, for the strength of a tire is in its fabric and as soon as the fabric becomes worn, cut, or damaged, the strength is gone. In this position, the fabric cannot be pieced as there is nothing to fasten to and nothing to cover it. If the rim cutting is discovered after but one layer of fabric is cut through, the tire can still be run, depending on the strength of the other layers, but with more than one cut, then

will not be sufficient strength to hold the tire together against the air pressure within.

Skidding and Quick Braking. When a tire which is almost new or at least in excellent condition shows at one point a very bad spot, Fig. 102, the surface rubber being worn through and that all around it scraped and worn, perhaps picked up or torn off in chunks in one or two places, this indicates one of two things, either very bad skidding or a too quick application of the brakes in stopping. That is, the car has slid along with the wheels locked either in a skid or by means of the brakes and this sliding has done the damage.

The writer has seen almost new tires, run but a few hundred miles, absolutely spoiled beyond hope of repair by the grandstand method of stopping a car all-standing, that is, driving fast right up to the point where it is desired to stop and then applying all the brakes with all the force applicable, in order to stop the car short. It stops the car short all right, but it also ends the life of tires just as shortly.

In a case of this kind when it comes to repairs, the only question is—How deep does the wound extend? If not too deep, that is, if none of the fabric is injured and if the entire surface abraded, and in addition that which is spoiled by the heat generated in such stops or slides, is not too large, an expert tire man can repair this by the stepping method. On the other hand, if too large for this, a sectional repair may be made unless the area effected makes this impossible also. This sectional repair is equivalent to rebuilding a portion of the tire. Even when well done it is comparatively weak and cannot be expected to last very long.

Even if the injury has been caused by skidding, the consequences are just as bad and the repair cost just as great. The writer considers skidding just as much the driver's fault as is the showy and quick stop, for when wet pavement or road is observed ahead, it is the driver's duty to slow down before he gets onto it. If he does not, the fault is his.



Fig. 102. Tear Due to Quick Braking

Referring back to the matter of quick braking of a car it should be stated that repeated tests have proved beyond a question of doubt that a car is not stopped as quickly when the brakes are applied suddenly and the wheels locked, as when the brakes are put on gently but firmly and progressively. In short, the quick method of braking not only damages the tires (and possibly other parts of the car by putting unusual strains upon them) but it is also poor driving for it is a poor and inefficient way to stop the car.

Chains Cut Tires. Everybody should, and most everybody does, use tire chains in wet weather over muddy roads and under such other conditions as make traction difficult or impossible for the smooth and slippery surface of the rubber tire. But not all persons use them wisely or well. It should be borne in mind that the chains are of metal and if left on when running over hard pavements or equally hard roads, instead of soft muddy ones on which they are supposed to be used, the metal links will cut the rubber. When properly applied, the chains should "float" around the circumference of the wheel, that is, within limits. By this is meant that they should not be fastened permanently in one place, nor under any circumstances should they be fixed to a spoke or spokes of the wheel.



Fig. 103.
Chain Cut Tire

When this is done, they stand in one place, the links are pressed down time after time onto the same part of the tread rubber and in a short time begin to dig in and cut there, Fig. 103. If continued long enough or if the chains are left on too long, this cutting will go right through to the fabric. Then the surface rubber, cut through in a dozen or more places by the numerous links, will begin to come off in small pieces. The only remedy for this is retreading and this is to be done only when the condition of the tire otherwise warrants it.

The way to use chains is to take them off as quickly as the need for them has passed. But the careful driver should be equally quick to put them on when a fresh need for them arises. Also, they

should be put on as loosely as is possible without striking the fenders or other parts of the car.

Tire Valves. In Fig. 98 there is shown a section through the tire valve but on a small scale. As this is a very important part and little understood, a larger view is shown in Fig. 104. This is in two parts, *A* at the left showing the valve closed and *B* at the right indicating the position of the various parts when the valve is open. Note that the lower part of the valve is hollow, so that air inside of the tire has access to the valve seat. Note that the valve is held down on this by the threaded portion above it. This valve seat forms a slight taper, which rests against an equally slight taper inside of the valve stem.

One condition of the tire valve holding air pressure is that the two valve seats be clean and smooth, free from scratches or cuts and foreign matter. Now it will be observed that the valve seat portion of the valve has a hole through the center in which the stem is a loose fit. This large hole passes all the way up through the threaded portion. The stem has a projection below the valve seat, which normally is held up against the bottom of the seat by the spring, this being strong enough to hold it up so tightly that no air can pass between the two. There are other conditions for valve tightness. The spring must be strong enough to hold these parts together; and the surfaces must be clean and true so that when held together, no air can get through.

Action of Valve. The action of the valve is this: When air is pumped in, it passes down around the central stem until it meets the projection, which it forces down against the pressure of the spring, and when there is air inside, against the pressure of the internal air. As soon as this is pressed down, the air passes in, and

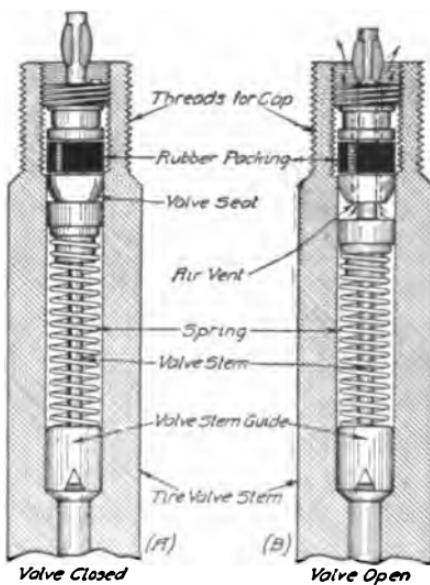


Fig. 104. Views of Tire Valve Showing Closed and Open Positions

if the external pressure is stopped, as at the end of a stroke of the pump, the spring and the internal pressure push the projection back into place, and no air can escape. On the next pressure stroke of the pump, this is repeated, the whole process continuing until the tire is filled.

Leaky Valves. It will be noted that with a good clean spring, projection, and valve seat, the pressure of the air itself holds the valve tight. Thus, when a valve leaks, it is a sure sign that some part or parts of it are not in good condition. If the valve is not screwed down far enough, air can leak out around the valve seat, so that leakage may be remedied by screwing the whole valve farther down into the stem. If the valve stem is too tight a fit in the central hole, it may stick in a position which allows air to pass. This can be remedied by a drop of oil placed on the stem and allowed to run down it. But not more than one drop should be used as rubber's greatest enemy is oil, and the tube with which the valve communicates is nearly pure rubber.

If the spring is too weak to hold the projection against the bottom of the valve seat, it will leak. This can be remedied by taking out and cleaning the spring, also stretching it as much as possible. In general, however, the best plan of action with a troublesome tire valve is to screw it out and put in a new one. These can be bought for fifty cents a dozen and every motorist should carry a dozen in a sealed envelope. Also a combination valve tool. When trouble arises with the valve, or a tire leaks down flat with no apparent cause, screw out the valve with the tool, screw in a new one, make sure it is down tight, and pump up again. The few cents it will cost to throw away a valve, even if it should happen to be good, will be more than compensated for by the time saved. Another point is that the whole valve assembly is so very small that it is difficult to handle.

Washing tires often is a good practice, for water does them no harm, while all road and car oils and greases will be cleaned off, nearly all of these being injurious. Frequent washing will also serve to call the owner's attention to minor defects while they are still small enough to be easily repaired and are thus prevented from spreading. When not in use, tires should be wrapped, so as to be covered from light, and put away in a dry room in which the tem-

perature is fairly constant the year round. They will not stand much sunlight, nor many alterations of temperature. Cold hardens the tires and causes rubber to crack. Heat has a somewhat similar effect and also draws out its life and spring.

In general, of all things to be cared for and repaired promptly, no one thing is of more importance than the tires. If this rule be kept in mind, better satisfaction in the use of the car will result. So, too, with other repair work, if tools and appliances are made available and repairs made as soon as needed, the car will be better understood and give more satisfaction than if the opposite course be pursued. A few short months' use of a car will do more to emphasize this than any amount of talk. Keep your car in good condition and you will reap the benefits of the little work you do upon it.

REPAIR EQUIPMENT

Vulcanization of Tires for Repair Man. In practically all of the following material the point of view is that of the professional repair man, or of the garage man about to take up tire repairs, as distinguished from that of the average owner or amateur repairer. The lesser tire injuries and their repairs are handled from an amateur standpoint in another part of this work.

General Rules for Tire Work. There are a few general rules which every rubber worker should observe, whether amateur or professional. These are: *Cementing*—the more thoroughly cement is worked into the surfaces to be united, the stronger the repair will be. *Drying*—the dryer the cement is allowed to become on cement-covered surfaces, the better the surfaces will unite when vulcanized. The cement acts as a flux and does not begin to vulcanize until dry. *Soapstone*—soapstone should not be permitted to get onto cement-covered surfaces as it will prevent their being vulcanized together. A little soapstone dusted on the inside surface of an inner tube, opposite a repair but not permitted to contact with the cementing surface, will prevent the walls of the tube from becoming vulcanized together. This is a precaution which should usually be taken, for when vulcanization occurs, the tube is practically ruined.

Vulcanization, to the uninitiated, sounds very mysterious but it really is nothing more or less than cooking or curing raw gum

rubber. In the processes of manufacture a tire is cooked or all the component parts supposedly being united into one complete whole. A tire is repaired preferably with raw gum or fabric prepared with raw gum, and in order to unite this to the tire, vulcanizing



Fig. 105. Small Vulcanizing Outfit for Single Casing or Six Inner Tubes
Courtesy of C. A. Shaler Company, Waupun, Wisconsin

or curing is necessary. The curing, in addition to uniting the parts properly, gives the proper strength, or wear-resisting qualities which raw rubber lacks.

Types of Vulcanizing Outfits. *Shaler Vulcanizer.* This outfit or cooking is done by the application of heat, in a variety of ways. Generally very small individual vulcanizers have a gasoline

alcohol cavity, holding just enough of the liquid so that when lighted and burned the correct temperature will be reached and held for the correct length of time. The larger units are operated by steam or electricity, the latter preferred for its convenience, the former used by the majority of repair men. The source of heat is immaterial so long as the correct temperature is reached and maintained for the right length of time. Too hot a vulcanizer will burn the rubber, too low a temperature will not give a complete cure.

For the average small repair man, the outfit shown in Fig. 105 will do very nicely, at least to start with. This will handle a single casing or six tubes, or in a press of work, both simultaneously. This outfit is operated by gasoline, contained in the tank shown above at the right, but the same outfit can be had with pipe arrangements for connecting to a steam main, or for electric heating. In the case of either gasoline or steam, there is an automatic temperature controlling device which is a feature of the Shaler apparatus. As shown, casings are repaired by what is known as the "wrapped tread method", the repair being heated from both inside and outside at once, the outside being wrapped. Tubes are handled on the flat plate shown in the middle of the framework, the size of this $4\frac{1}{2}$ by 30 inches being sufficient, so the makers say, to handle six tubes at once. When this is used, the tubes are hung over the top pipe of the machine, only the injured portion resting on the plate.

Haywood Vulcanizer. For larger work, a machine something like the Haywood Master, shown in Fig. 106, is excellent. This is a self-contained unit, carrying its own gasoline tank, steam generator, and other parts. It handles four casings at once, while the tube plate *G* is 5 by 18 inches, large enough for from three to four tubes according to the allowance per tube made in the Shaler outfit. The separate vulcanizers are not designed for the same part of a casing, a side wall and bead vulcanizer being shown at *D*, a sectional vulcanizer for large sizes at *E*, a sectional vulcanizer for small and medium sizes at *F*, and a side wall and bead vulcanizer for both clincher and straight side tires at *H*. The gasoline tank is marked *C*, with vertical pipe in which is the gasoline cut-off valve *K*. This leads down to the gasoline burner *M*, where the gasoline in burning vaporizes the water into steam. The water gage which indicates the amount of water available is marked *L*, this being placed on the

side of the steam generator *A*. Above this is the steam dome at *B*, from which the steam pipes lead to the various molds. The returns or rather drips will be noted, also the steam gage not marked, and the cut-off valve in the supply pipe to the sectional molds. In addi-



Fig. 106. Master Vulcanizer with Self-Contained Steam Generator
Courtesy of Haywood Tire and Equipment Company, Indianapolis, Indiana

tion to the molds shown and a full supply of parts and tools, sectional vulcanizers for $2\frac{1}{2}$ - and 3-inch tires, relining mold for $2\frac{1}{2}$, 3-, and $3\frac{1}{2}$ -inch tires, and relining mold for 4-, $4\frac{1}{2}$ -, 5-, and $5\frac{1}{2}$ -inch casings come with the device. The smaller sizes mentioned are cycle and motorcycle tires, and there is less repairing to be done on these.

This outfit with the extra molds, described but not shown gives a very complete equipment for the small shop, doing average

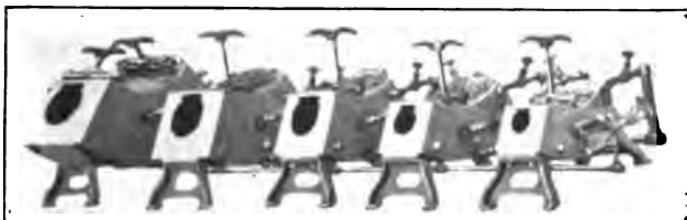


Fig. 107. Battery of Vulcanising Molds for Various Sizes of Tires

repairing. In fact, when a shop outgrows this type of equipment, it must specialize in tire work, and purchase special equipment, as for instance separate molds for casings only, separate plates for tubes only, separate side wall vulcanizers, separate tread outfits, separate relining outfits, etc., and as all these require a large supply of steam, a separate boiler, and the whole equipment properly and safely arranged, with proper piping, suitable returns, gages, etc.

Separate Casing Molds for Patch Work. In the way of separate molds for casings, an excellent example of the localized heat type is shown in Fig. 107. By this is meant, the form designed to vulcanize a small short section of a tire. The illustration shows five sections capable of handling, respectively, $2\frac{1}{4}$ - to 3-inch (motorcycle), $2\frac{1}{2}$ - to 3 (small car), $3\frac{1}{2}$ - to 4-inch, $4\frac{1}{2}$ - to 5-inch, and $5\frac{1}{2}$ - to 6-inch tires, thus covering the entire range. These molds have a special arrangement, in that the heating portion is divided into three sections, into each of which steam can be admitted separately. This allows the use of one, two, or all the sections according to the nature of the repair.

In Fig. 108 is shown how it is possible with this apparatus to vulcanize the tread portion only by admitting steam solely to the larger bottom steam chamber around the tread. Similarly with the right-hand bead or side wall, or the left-hand bead or side wall. When a complete section is to be vulcanized, all sections are opened. The



Fig. 108. Section of Vulcanizer, Showing Steam Cavities

importance of this will be realized in a simple consideration of the fact that the tire itself has already been vulcanized and further heat

is not only not good for it, but is distinctly bad, as it deteriorates the rubber. Where the heat is needed, however, is on the raw rubber which has just been added at the repair point, this being practically useless until it has been cured.



Fig. 109. Vulcanizing Kettle, Horizontal Type

kettle shown in Fig. 109, has a capacity of two casings 36 inches in diameter or smaller. It is of the type in which no bolts or nuts are used for fastening the cover, this being held fast by the projecting lugs which lock under other projections on the top of the

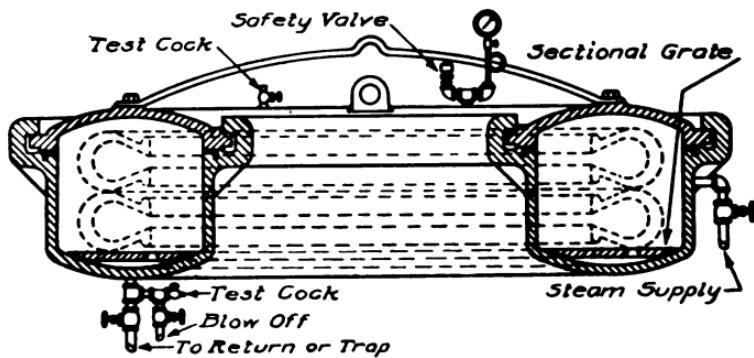


Fig. 110. Section of Horizontal Vulcanizing Kettle

kettle, when the cover is turned, Fig. 109. A special rubber packing ring is also used, as shown in Fig. 110, effectually sealing the kettle

against steam leakage. It will be seen that this kettle resembles a doughnut in shape, the tires lying within the circular cavity as shown in Fig. 110.

Large Vertical Type. When the work goes beyond the capacity of size and type of tank or kettle shown in Fig. 109, which will handle two casings at a time, and at least two, perhaps four, kettles full an hour—that is, from 40 to 75 casings a day—it becomes necessary to use a larger type of kettle, made in vertical types only. These consist simply of large round steel shells with hinged heads, into which the tires can be rolled and piled, after which steam is admitted to the whole interior. They vary in size from 36 inches inside diameter by 24 inches in length to 48 inches diameter by 40 inches in length. The last named handles from six to eight casings and up to 42 inches in diameter, the others relatively less in size and number.

Inside Casing Forms. Another requisite of the tire specialist is an inside casing form, such as is shown in Fig. 111, or something

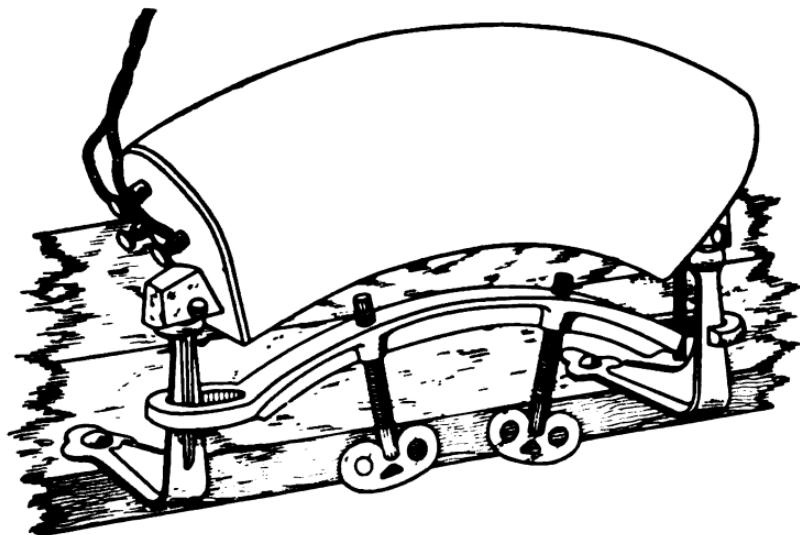


Fig. 111. Shaler Electrically Heated Inside Casing Form

similar. Many tire repairs are inside work, and even on those which are external, it is important to have an inside form against which the tire can be pressed and held firmly while vulcanizing. This particular form is heated by electricity, the wires being shown at the left; it is 14 inches long and has an external shape to fit the inside of all casings.

Side-Wall Vulcanizer. A shop doing a great deal of work can use to good advantage the side wall vulcanizer shown in Fig. 112.

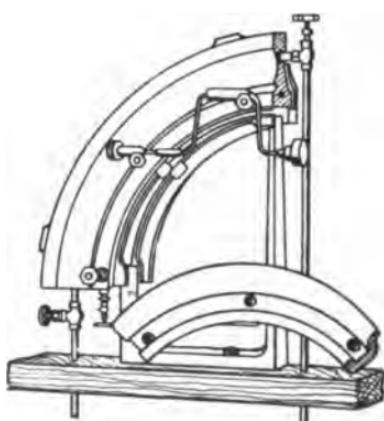


Fig. 112. Side-Wall Vulcanizer

This has a single central member through which the steam passes, and has also bolted-on side plates, the insides of which are formed to suit either clincher or straight side tires. In the figure, the side plates are not both in place, one being shown below on the work table. The brace shown is used to remove the clamping nuts quickly and easily. This form is very useful on all side wall or bead operations. It applies greater pressure along these parts of the tire than an



Fig. 113. Retreading Vulcanizer with Tire in Position
Courtesy of Haywood Tire and Equipment Company, Indianapolis, Indiana

air bag can; it exactly fits the tire and the size and shape make it possible to vulcanize a 36-inch tire in four settings.

Retreading Vulcanizers. Retreading vulcanizers differ from the sectional molds of Figs. 105, 106, and 107 in that the heat is applied at one particular point or, rather, strip along the middle of the top surface of the casing and extending down only as far as the side walls. Such a device, shown in elevation in Fig. 113, and in enlarged sectional detail in Fig. 114, is used solely for retreading or vulcanizing a new tread strip around the tire. The complete unit extends around about one-third of the whole tire surface so that, when putting on a complete new tread the mold must be used three times. The section, Fig. 114, is numbered as follows: Casting, 2; inner mold, 1; new tread to be vulcanized, 3; vulcanizer proper, 4; clamp, 5; and steam space within which the heating is done, 6.

Layouts of Equipment. There are two ways of installing an outfit somewhat like that just described, namely, by the non-return system and by the gravity-return system.

Non-Return Layout. A typical installation according to the non-return system is shown in Fig. 115. A steam trap must be placed in the system to remove the water

and discharge it either into the sewer or into a tank so that it can be used again. In the figure there is shown a tube plate, a three-cavity sectional vulcanizer, two inside molds, and a medium-sized kettle of the vertical type, placed in order from the right to left. A pressure-reducing valve is shown as this permits of carrying a higher pressure in the boiler, reducing it to the amount required for the vulcanizers. This will maintain an

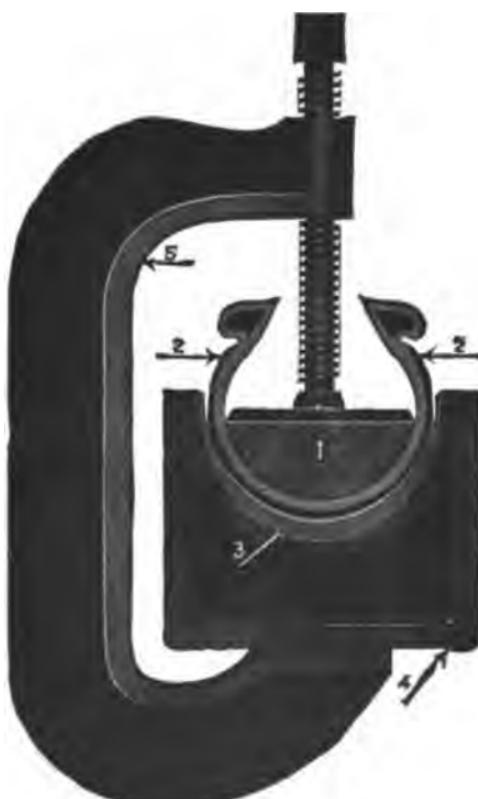


Fig. 114. Section of Retreading Vulcanizer
Courtesy of Haywood Tire and Equipment Company,
Indianapolis, Indiana

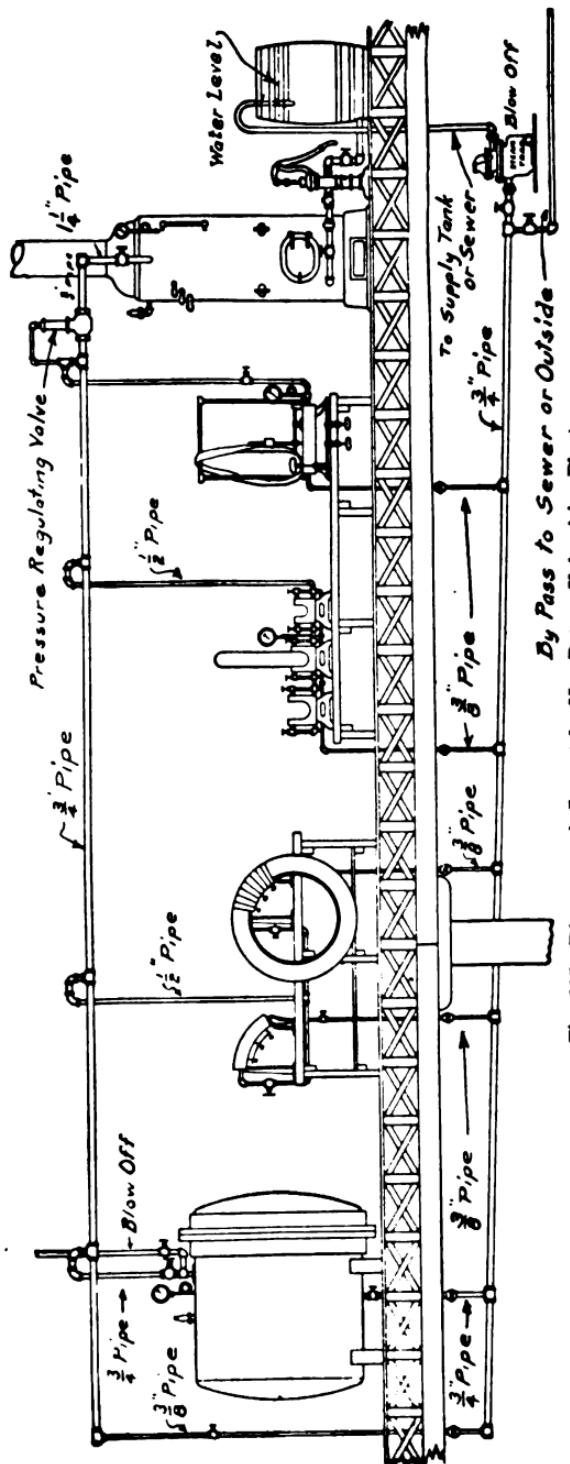


Fig. 115. Diagrammatic Layout for Non-Return Vulcanizing Plant

even steady pressure on the vulcanizers regardless of fluctuations at the boiler.

Gravity-Return Layout. When the coil steam-generator, or flash type of boiler is used, the gravity-return system is utilized, this being a method of piping by means of which the condensed steam is returned to the coil heater to be used over again. This makes it necessary to set the apparatus so that the water of condensation will run back to the coil heater, which means that the pieces must be in a series, each successive one being set a little lower down to the boiler. Figs. 116 and 117 show a side view and plan view, respectively, of a small plant arranged on this plan. The outfit consists of the coil heater, which may be fitted to burn gas or gasoline, two inside molds, a large

tube plate, and a three-cavity sectional vulcanizer. The outfit differs from Fig. 115 only in the absence of the kettle; on the other hand, the tube plate in Fig. 116 is larger.

Small Tool Equipment. In addition to these larger units, the well equipped tire repair shop should have a considerable quantity

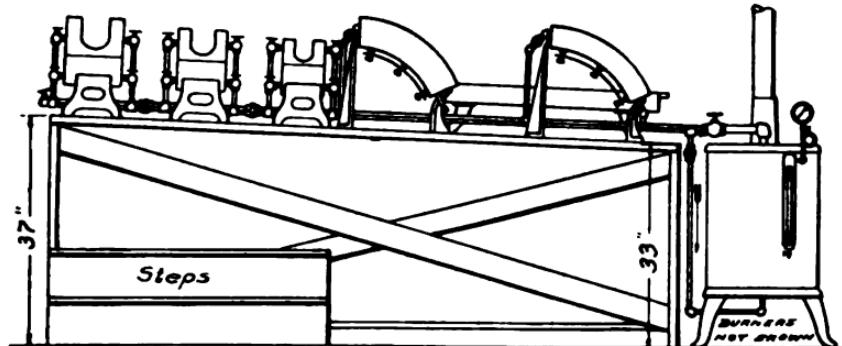


Fig. 116. Elevation of Gravity-Return Vulcanising Plant

of small tools, among the necessities being those shown in Fig. 118. At *A* is shown a flat hand roller, and at *B*, a concave roller. *C* shows an awl or probe which is used for opening air bubbles and sand blisters. *D* is a smooth stitcher; *F* a rubber knife, of which two sizes are advisable, a large and a small; and *G* a 10-inch pair of shears for trimming inner tube holes, cutting sheet rubber, etc. *H* is a steel

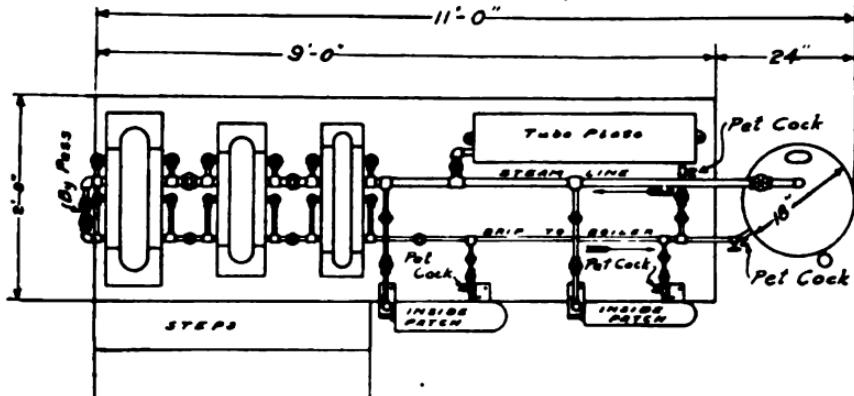


Fig. 117. Plan View of Gravity-Return Vulcanizing Plant

wire brush for roughing casings by hand; a preferable form is a rotary steel wire type driven by power at high speed. *I* is a similar wire brush for roughing tubes; and *J* another brush with longer

wires, also for roughing casings; *K* is a tread gage for marking casings to be retreaded; and *L* a fabric knife necessary in stepping down plies of fabric. *M* is a pair of plug pliers for placing patches inside of small tube repairs; *N* is a cement brush for heavy casing cement, another very much smaller and lighter one—preferably of the camels' hair type—being used for tube cement. *O* is a hand scraper and *P* a tread chisel; *Q* performs a somewhat similar function.

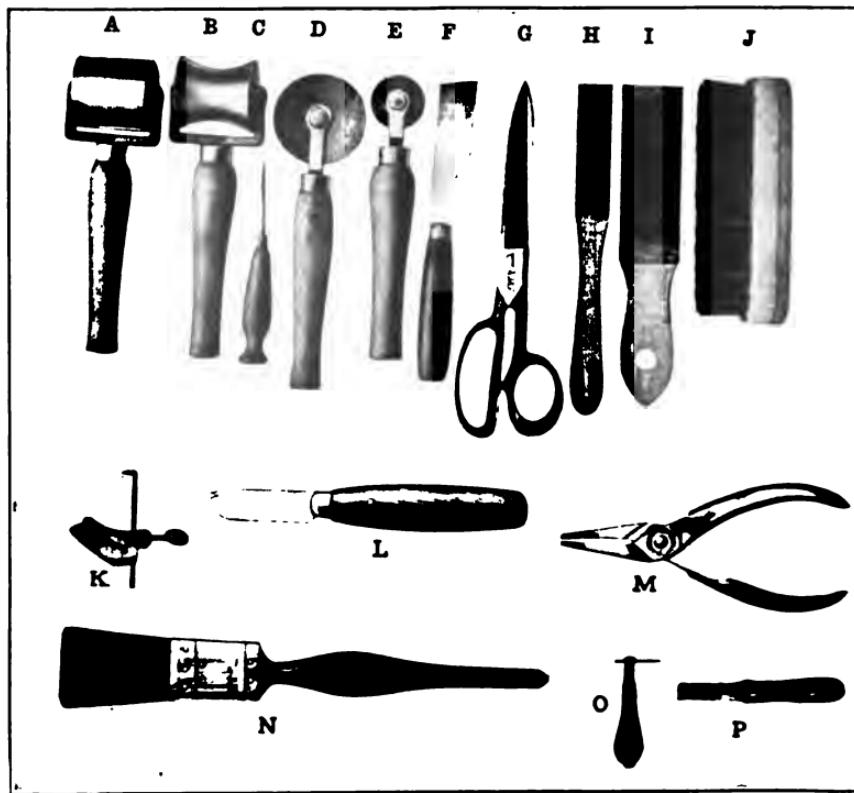


Fig. 118. Collection of Tools Necessary for Vulcanizing Work

being a casing scraper for cleaning the inside of a casing preparatory to mending a blow-out.

In addition to the small tools shown in Fig. 118, it is necessary to have several tube-splicing mandrels; a large number of various-sized and shaped clamps for all purposes; rules, try squares, and other measuring tools; tweezers for handling small patches, tools for recutting threads on tire valves; tire spreaders, for holding casings open when working inside; a casing mandrel or tire last of cast iron

for holding a casing when making repairs; a tread roller for rolling down layers of raw stock evenly and quickly; a considerable amount of binding tape; thermometers; and such motor-driven brushes, scrapers, etc., as the quantity and quality of the work warrant.

Materials. Each repair shop must carry such a supply of tire-repairing material as the nature and quantity of its business demands. Among other things may be mentioned: Tread stock, rebuilding fabric, single-friction fabric, cushion stock, breaker strips, single-cure tube stock, combination stock, cement, quick-cure cement, soapstone, valve bases, valve insides, valve caps, complete valves, vulcanizing acid, various tube sections, tire tape, cementless patches, as well as many other tire accessories to sell. Many good tire repair shops find a legitimate use for special tire repairing preparations on the order of Tire-Doh.

INNER TUBE REPAIRS

In general all tire repairs come under one or more of the following headings: Puncture; blow-outs; partial rim cut or rim cut all around; and retreading or recovering, and relining.

Simple Patches. Under the heading of punctures, are handled all small holes, cuts, pinched tubes, or minor injuries. Generally these can be repaired by putting on a patch by means of cement, or with cement and acid curing. When well done, this method is effective. This kind of a job seldom comes to the repair man, and when it does it is principally because the owner is too lazy to do the work. About the only two cautions necessary are relative to cleanliness and thoroughness. The tube and patch should be thoroughly cleaned. Again the patch should be large, well cemented, and the cement allowed to dry until just sticky enough to adhere properly. Many a simple patch of this kind has been known to last as long as the balance of the tube.

Large Patches. *Cleaning the Hole.* Whenever the hole or cut is large, it is recommended that the repair be given more serious attention and vulcanized. The ragged edges of the rubber should be trimmed smooth with the tube shears or knife, the minimum amount of rubber being cut away. The hole, however, should be made large enough to allow the insertion of an inside patch. Then the tube around the hole should be cleaned thoroughly. This is best

done with a cloth wet with gasoline, cleaning not only the outside but the inside around the hole and at the edges. In order to make a good job of this, it should be gone over several times; the larger the hole the more care should be used in cleaning around it.

Preparing the Patch. Having the hole well cleaned and ready, these cleaned parts should be painted with two coats of vulcanizing cement, which is allowed to dry. *This must be thoroughly, not partly dry.* Then the proper patch is selected, the smaller size being sufficient for small patches, while in the case of large repairs, the patch should be from $\frac{1}{2}$ to 1 inch larger all around than the hole. If this is not a prepared patch, one side should be cemented just as the tube was previously. If a prepared patch is used, the semi-cured side should be placed in, that is, with the sticky or uncured side toward the tube from the inside.

When the cement on the patch is just sticky enough it should be inserted and the tube pressed down against it all around, slowly and carefully so as to get good adhesion. Next the cavity about the inside patch is filled with gum or pure rubber, preferably in sheet form as it comes for this purpose. This is filled in until the surface is flush. It is preferable to use a little vulcanizing cement to hold this rubber in place, particularly if a piece of sheet gum is cut to fill the hole.

Vulcanizing the Patch. The repair is now about half completed, and is next vulcanized. The length of time, if steam is used, varies with the amount of steam pressure; if the portable gasoline or alcohol type of vulcanizer is applied the time varies with the temperature. As this time variation is so wide, it is impossible to give an invariable rule. Thick tubes require a little longer than thin ones, large patches longer than small ones, wide patches more than narrow, etc. The vulcanizing must be carefully and thoroughly done, and as the success of the whole job depends upon this one process, the arrangement of the tube on the plate, of the soapstone on the new rubber, and on the vulcanizer to prevent adhesion, of the wood or rubber pad above the patch, of the clamp and its pressure, should all have careful attention. With 60 pounds' steam pressure available, from 10 to 12 minutes is about right, with 75 pounds from 8 to 10 minutes. In any case, the rubber should be cured just firm enough not to show a slight indentation from the point of a lead pencil. This is a good

test to use at first, although after a short experience, the workman will be able to judge of the condition from the feeling, color, and general appearance of the patch.

When the size of the plate is small, the tubes should be held up above it out of the way, partly to allow the full use of the plate surface, but also to keep the tubes from being damaged.

Inserting New Section. *Preparing the Tubes.* In case the damage to the tube is too great to permit the use of a patch—for instance, in case a blow-out makes a wide hole perhaps 7 inches or more long in an otherwise good tube—it is advisable to cut out the damaged section and insert a new section in its place. Sometimes old tubes of the same size can be used for this, but if not, sections can be purchased from the larger tire and rubber companies.

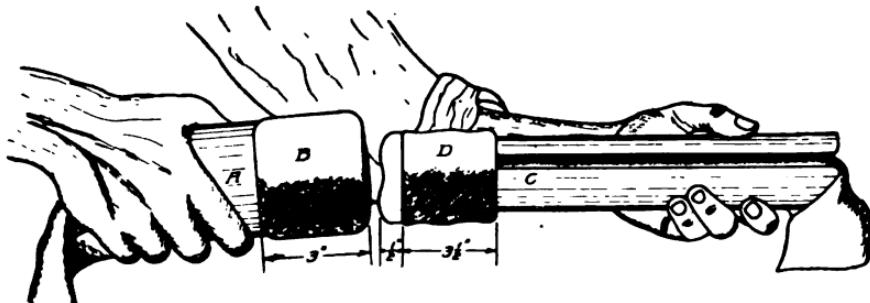


Fig. 119. Sketch Showing Method of Inserting New Section in Inside Tube

In the repair, proceed as follows: After cutting out the damaged section, bevel down the ends very carefully, using a mandrel to work on and a very sharp knife. As the appearance and to a large extent, the value of the repair will depend upon these beveled ends, this should be done in a painstaking manner. Next select the tube section and cut it to size, that is, from 5 to 6 inches longer than the section which was cut out and which this patch is replacing. This allows $2\frac{1}{2}$ to 3 inches for the splice at each end. Bevel the ends of the tube as well, and after beveling all four ends, roughen them with a wire brush or sandpaper.

Making the Splice. Having the tube and repair section beveled, and buffed, the ends to be joined should be coated with one heavy or two light coats of acid-cure splicing cement. With the tube and patch properly placed on the mandrels—tube on the male and patch on the female—turn back the end to be repaired and the end to be

applied as shown in Fig. 119. At *A* is shown the female mandrel on which is the patch *B*, turned back from the end of the mandrel about the right distance, say 3 to $3\frac{1}{2}$ inches. At *C* is the male mandrel on which the tube *D* has been turned back about 7 to $7\frac{1}{2}$ inches, then turned back again on itself about 3 to $3\frac{1}{2}$ inches.

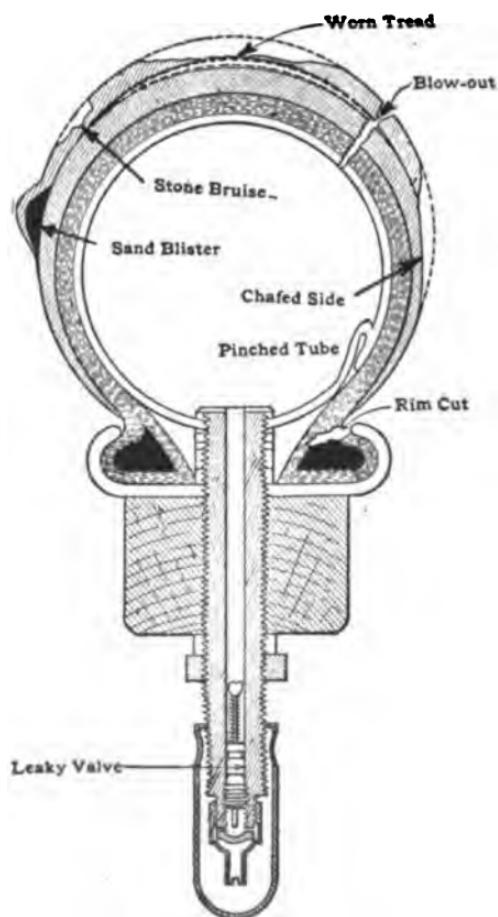


Fig. 120. Section of Tire, Showing Forms of Troubles

together well, it indicates either that the acid supply is poor or else the splicing was not done quickly enough after applying the acid.

CASING REPAIRS

Classifying Troubles. Some of the common tire troubles—those of the inner-tube variety just discussed, and casing troubles as well—can be clearly shown by suitable illustrations. For example, a section through the tire showing how the troubles occur is some-

Just as soon as the cement has dried thoroughly on the tube, apply a coat of acid to the patch, and immediately place the two mandrel ends together, and snap, blow, or push the end of the patch over onto the end of the tube. This frees the female mandrel which can be laid aside. Immediately wind the patched portion (still on the male mandrel) with strips of muslin or inner tubing. In 15 to 20 minutes the cement will have formed a permanent union, the wrappings can be removed, and the tube withdrawn through the slot in the mandrel.

This done successfully, the whole operation is repeated for the other splice. If the splice does not cure

times very useful, as shown in Fig. 120. Here the pinched tube and blow-out are indicated, the results of these on the inner tube and also their method of repair having just been described. These troubles together with punctures, leaky valves, and porous rubber in the tubes about cover the extent of inner tube troubles. Because of their more complex construction, casings have more numerous and more varied troubles, which, consequently, are more difficult to repair. The more common casing troubles are blisters, blow-outs, rim cuts, and worn tread, the latter indicating the necessity for retreading. These will be described in order.

Sand Blisters. The sand blister shown on the side of the tire, Fig. 120, is brought about by a small hole such as an unfilled puncture hole, in combination with a portion of the tread coming loose on the casing near this hole. Particles of sand, road dust, dirt, etc., enter, or are forced into, this hole, and move along the opening provided by the loose tread. Soon this becomes continuous and the amount of dirt within the break forces the surface rubber out in the form of a round knob known as a sand blister. This is cured by cutting open the blister with a sharp knife on the side toward the rim, and picking out all dirt within. When the recess is thoroughly cleaned, the hole, and the radial hole in the tire tread nearby, should be filled with some form of self-curing rubber filler, a number of kinds of which are sold. The double benefit of this is to close the hole so that the trouble is not repeated, and to keep out moisture which would ultimately loosen the entire tread. A small stone bruise should be filled in the same manner.

Blow-Outs. The blow-out, which is perhaps the most important casing repair, may be made in two ways; the inside method in which the whole repair is effected on the inside, or the combination inside and outside method.

Inside Repair Methods. Refer back to Fig. 120 for the general tire construction, and to Fig. 121 for this particular case, the inside of the tire is held open by means of tire hooks and the inside fabric layers or plies removed for a liberal distance on each side of the opening. As shown in Fig. 121, a lesser amount of the second layer should be taken than of the first, and still less of the third and each subsequent one. On $3\frac{1}{2}$ - and 4-inch tires it is not advisable to remove more than two plies; on $4\frac{1}{2}$ -inch tires three as shown; and on the larger

sizes four plies. The edge of each layer of fabric should be beveled down thin, as well as the material directly around the blow-out.

Apply a coat of vulcanizing cement and when it has dried, say for an hour, apply another. When this has dried enough to be sticky or tacky, fill as much of the hole as possible with gum. When this is filled in level, apply the fabric patch. This is made up to match the fabric cut-out; that is if three layers are removed, it should

consist of three plies stepped-up to match, and an extra last ply of bareback fabric unfrictioned on one side. This last layer should extend $3\frac{1}{2}$ to 4 inches beyond the ends of the patch.

When this is properly applied and carefully smoothed down, the tire is placed in a sectional mold, clamped in place, perhaps wrapped with muslin strips to hold it tightly against the mold, and heat applied from the inside. This makes an excellent repair and a fairly quick and easy one but is not applicable for large blow-outs; at least it is not as effective as the inside and outside method.

Inside and Outside Method. In the inside and outside method, the material is removed from the outside, stepped down, and beveled in the same manner as for the

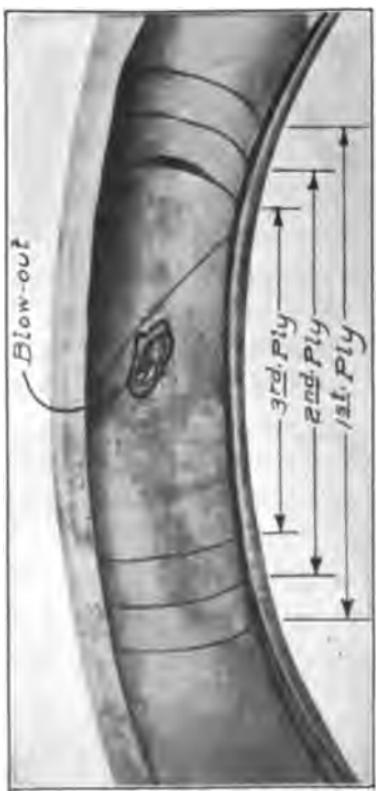


Fig. 121. Method of Preparing Layers of Fabric for Patching Blow-Outs—Inside Method

method just described. Fig. 122 shows a tire with a medium sized blow-out, which has been stepped down for a sectional repair, four plies having been removed. The rule for the number of plies to remove is about the same as before, except that in the larger sizes this should depend more on the nature of the injury. It should be noted, however, that in this case the plies have all been removed right down to and including the bead. This is done to give the new fabric a better hold, and to make a neater job and one that

will fit the rim better. Give the whole surface two good coats of vulcanizing cement, allowing it to dry thoroughly.

Apply the same number of plies of building fabric as were removed, with the addition of chafing strips of light-weight fabric at the bead. Over this building fabric apply a thin sheet of cushion gum, slightly wider than the fabric breaker strip; then a thickness of fabric breaker strip over this; and then over this fabric another sheet of gum, slightly narrower than the previous sheet. All this, however, should be built up separately and applied as a unit and not at a time, as described. These several plies should be well rolled together on the table. All edges should be carefully beveled off especially the edges of the new gum where it meets the old, as it is

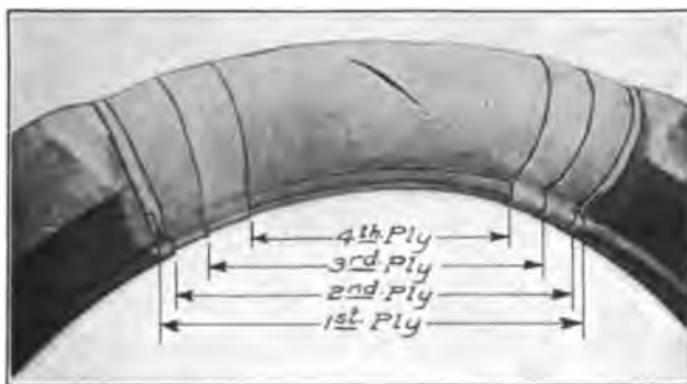


Fig. 122. Method of Preparing Fabric for Blow-Out Patch—Inside and Outside Method

likely to flow a little and leave a thin overlap which will soon pick loose.

No fabric is removed from the inside, but the hole is cleaned, its edges beveled, then filled with tread gum, and the inside reinforced with a small patch of building fabric; over this lay two plies of building fabric of considerable size. Now the whole casing is placed in a sectional mold, a surface plate applied to the outside, and heat applied both inside and outside. This will heat the tire clear through and make a good thorough job of curing.

Rim-Cut Repair. Partial Cut. To repair a partial rim cut, one or two plies of the old fabric are removed, unless it is severe, when three plies may be taken off. This is removed right down clean as explained under Blow-Out Repairs, and the cement and new

materials applied in the same way, with the omission of the fabric breaker strip. However, care should be used to carry all building fabric layers not only down around the bead to the toe but up on the inside far enough to secure a good hold and ample reinforcement. If this should make the rim portion somewhat more bulky, remember it was a case of doing this or getting a new tire.

Complete Rim Cut. Where the rim cutting is continuous, the old side-wall rubber is removed up to the edges of the tread, and



Fig. 123. Method of Handling Rim Cuts

the old chafing strips and one ply of old fabric to about an inch above the beads removed also. Cut through the side wall rubber all around but be very careful not to cut into the fabric body or carcass. The whole of the side wall and chafing strips can be removed in one operation. Apply two coats of cement and after this is thoroughly dry put on a patch consisting of one ply of building fabric, one ply of

chafing strip, and a surface or outside ply of new tread gum. This is made on the table and the parts thoroughly rolled together. When completed, vulcanize in a sectional mold with sectional air bag and bead molds or endless air bag; apply to a split curing-rim wrap, and vulcanize in heater or kettle. The tire is repaired, but not vulcanized, and with the ends of the three applied plies of material loosened to show, may be seen in Fig. 123.

Retreading. Retreading is a job which must be done very carefully, not only because of the job itself, but also because this is probably the most expensive single job which can be done to a tire, and the worker should make sure before starting that the tire warrants this expense. It should have good side walls and bead, and the fabric should be solid and not broken apart.

Repairing the Carcass. In the usual case, it is advisable to remove not only the surface rubber and fabric breaker strip, but also the cushion rubber beneath the breaker strip. That is, the tire should be cleaned off right down to the carcass and the latter cleaned thoroughly. As the rubber sticks, a rotary wire brush will be found useful and quick. However, this should be used carefully so as not to gouge the carcass. After buffing, the loose particles of rubber should be removed with a whisk broom or dry piece of muslin. In this cleaning work the carcass should be kept clean and dry. Apply two coats of vulcanizing cement and allow both to dry; the first should be a light coat to soak into the surface fabric; the second should be a heavy coat.

Building Up the Tread. In building up the tread, it should not be made as heavy as the former tread, as the old worn and weakened carcass cannot carry as heavy a tread as when new. Furthermore, it takes longer to vulcanize a heavy tread and presents more opportunity for failure. In the building-up process, the proportioning of weights is important, and should be taken from the tabulation below, which represents years of experience in tire repairing:

Size of Case	Ply toward Fabric	2nd Ply	3rd Ply	4th Ply	5th Ply	Last Ply Overall	Complete Tread Consists of
3 "	2 $\frac{1}{2}$ "	3 $\frac{1}{2}$ "				*See Note	3 plies
3 $\frac{1}{2}$ "	2 $\frac{1}{2}$ "	3 $\frac{1}{2}$ "	4 $\frac{1}{2}$ "			"	4 "
4 "	3 $\frac{1}{2}$ "	4 "	4 $\frac{1}{2}$ "			"	4 "
4 $\frac{1}{2}$ "	4 "	4 $\frac{1}{2}$ "	5 $\frac{1}{2}$ "			"	4 "
5 "	4 $\frac{1}{2}$ "	5 "	5 $\frac{1}{2}$ "	6 $\frac{1}{2}$ "		"	5 "
5 $\frac{1}{2}$ "	4 $\frac{1}{2}$ "	5 $\frac{1}{2}$ "	6 $\frac{1}{2}$ "	7	7 $\frac{1}{2}$ "	"	6 "
6 "	5 $\frac{1}{2}$ "	6 "	6 $\frac{1}{2}$ "	7 $\frac{1}{2}$ "	8 $\frac{1}{2}$ "	"	6 "

* Note: Determined by condition of case after buffing and cementing.

Size of Case	Width of Breaker Strip
3 "	1 $\frac{1}{2}$ "
3 $\frac{1}{2}$ "	2 $\frac{1}{2}$ "
4 "	2 $\frac{1}{2}$ "
4 $\frac{1}{2}$ "	3 "
5 "	3 $\frac{1}{2}$ "
5 $\frac{1}{2}$ "	4 "
6 "	4 $\frac{1}{2}$ "

This tread strip is built up on the table with exceeding care, all edges being rolled down carefully. When the strip has been

prepared and the carcass is ready for it, one end should be centered on the carcass, and then the balance of the strip applied around the circumference, being careful to center it all around, as the workman in Fig. 124 is doing. After it has been applied all around, it should be rolled down carefully, all air pockets opened with a sharp pointed awl, and the gum at the edges of the plies rolled down with the corrugated stitcher. When ready, vulcanize in a kettle, using an endless air bag with tire applied to a split curing-rim, and wrapped—preferably double wrapped—all around.

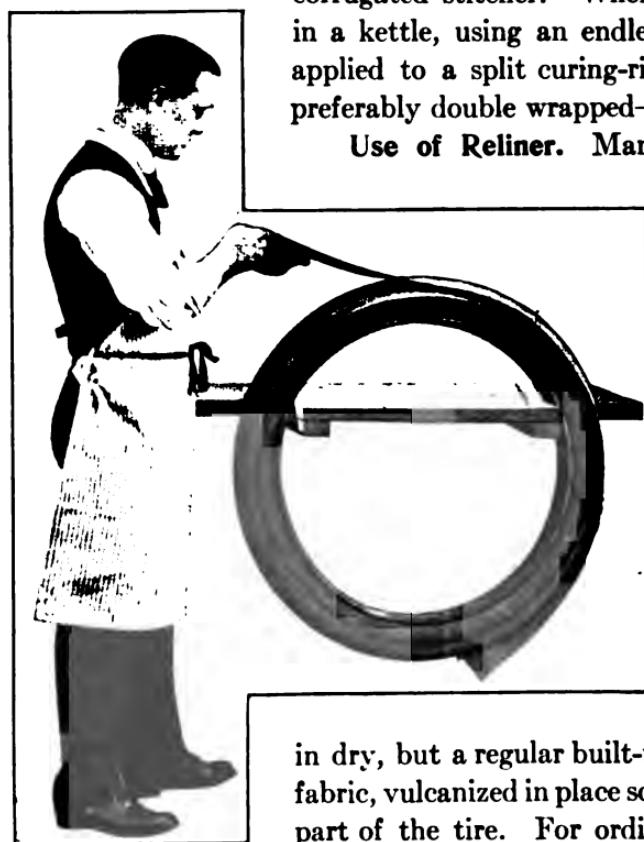


Fig. 124. Method of Putting On New Tread

Use of Reliner. Many a casing which appears good on the outside but which really is unsafe because of fabric breaks on the inside can be saved, or its life temporarily prolonged, by the application of a reliner. By this is not meant the prepared canvas and fabric reliner which can be put

in dry, but a regular built-up strip of building fabric, vulcanized in place so as to be an integral part of the tire. For ordinary breaks, use a single ply of building fabric on a casing which has been entirely cleaned out and which has had two coats of vulcanizing cement, thoroughly dried in. In the case of a bad break, use two plies of fabric, stepping them to fit; the under ply should be frictioned on two sides and coated on one, and the upper ply should be frictioned on one side only, the side toward the tube being bareback. Use an endless air bag for internal pressure, apply to a split rim, wrap, and vulcanize in kettle from 35 to 45 minutes at 40 pounds steam pressure.

Summary. By the application of parts of the foregoing instructions and the use of much common sense, coupled with a knowledge of the construction, use and abuses of tires, the repair man will be able to handle any form of tire repair brought to him. In starting out, perhaps he could not do a better thing than to take an old tire apart to see just how it is constructed. This will give a much more clear idea than any number of diagrams, sketches, or photographs.

The tire repair man should remember too, that this is no longer a game, but that, by means of scientific apparatus and the application of correct principles, it has been brought up to a high state of perfection; an expert can predict with reasonable accuracy what will happen in such and such a case, if this and that are not done. In short, the tire repairing business within the last few years has been brought up to a stage where it, or any part of it, is a dependable operation. The tire repair man should handle all his work from this advanced point of view; it will pay in the long run.

SUMMARY OF TROUBLES AND BREAKDOWNS

The preceding sections on the repair of the various parts of the automobile may not perhaps solve all of the situations which will develop in connection with your machine, but they should help to correct most of the difficulties and their observance will keep the car in good running order. There are many times, however, when it is necessary to locate the source of trouble without delay. At such times poring over page after page of material in order to find the case in point is rather discouraging and a briefer presentation of the possible difficulties, such as the following, is more useful. After the trouble has been located and more information is desired, the complete sections may be consulted.

TROUBLES WITH THE RUNNING GEAR

Adjustments. Adjustments of any loose or rattling parts must be promptly made. Intelligent care in this respect prevents trouble.

Axle Bearings. Axle bearings must be examined after a run of a number of miles to see that they are not overheated.

Cleaning. All moving parts must be kept clean. Oil collects dust. Dust and oil cause unnecessary and excessive wear.

Rims. Rims of wheels must be examined often to see that they

are not sharp edged. If sharp, they must be filed dull and smooth. Never let rims get rusty. Carefully paint them on the inside.

Tires. Tires must be kept properly inflated. If a tire becomes flat on the road, stop the car as soon as possible, as running on a flat tire is almost certain to seriously injure or destroy it. Remove the tire from the wheel, and if, on examination, it is found that the inner tube is punctured, put in a new one. Never try to patch an inner tube on the road unless absolutely obliged to do so for the patch is pretty certain to come off after a few miles of driving. If you have no extra inner tube, you can do either one of two things: first, patch the damaged inner tube and re-inflate the tire; second, remove the tire altogether and run in on the rim. The latter course is entirely permissible and feasible provided the car is run at a slow speed, say, from four to ten miles an hour according to the surface of the road.

Tires cannot be inflated as tight in hot weather as in cold on account of the expansion of the air due to heat. After pumping up to full pressure, permit a slight amount of air to escape through the valve.

Tires, when not on the car, should be kept in a dry place and wrapped. Never leave them in a damp place or they will quickly rot beyond remedy.

Tires on a car which is to remain in-doors for some time should be protected by placing a jack under the axle and letting the air escape, the car being left with the axles resting on the jack or blocks and not on the wheels. Otherwise the rim pressing on the tire covers will seriously damage them.

In washing a car, do not let water enter the tires. It is likely to cause the fabric to rot, although it does not harm the rubber.

Do not put leather or chains on one rear wheel only. Both rear wheels must be alike in this respect or you may possibly damage your differential.

Wheel Bearings. If these are ball bearings they should be lubricated with hard grease once a month; if roller bearings, they should be oiled at least twice a week.

Heated Wheel Bearings. If any of the wheel bearings heat up it is a sign of insufficient lubrication. Do not run car until axle is perfectly cool, then apply plenty of hard grease and watch it carefully. If there has been considerable cutting of bearings they may have to be sent to the makers, but never to the ordinary machine-shop.

Tight Brakes. Refusal of the car to run easily or to climb hills may be due to brakes binding. Adjustment of tension springs will remedy this, also some oil should be kept on them.

ENGINE TROUBLES

Deposits of Carbon in Cylinder. These are loosened by introducing two or three tablespoonfuls of kerosene, put in cylinder when warm through spark plug hole. Replace spark plug but do not connect up the wires. Turn engine over slowly to work kerosene back of rings. Allow engine to stand a few minutes. Then connect wires and start running out of doors as dense smoke will come for a time. Clean spark plugs and replace.

Knocking. Knocking should not be permitted. It is liable to result in injury to the engine. Ordinarily knocking is avoided by retarding the spark. In starting up a hill where considerable power will be needed, an open throttle with advanced spark should be employed before beginning the climb. Should the motor begin to knock when part way up the hill, the spark should be gradually retarded. Continued pounding is caused by the connecting-rod and main shaft bearings becoming loose.

Failure to Start. Try the following remedies:

See that current is switched on.

See if throttle valve is open.

Be sure gasoline tank is filled.

Be sure gasoline valve is open.

See that air can enter filling cap of gasoline tank.

Flood carbureter.

If weather is cold, prime cylinders by squirting a little gasoline in through each compression relief cock.

See that spark plugs are clean.

Missing of Explosions. See "Troubles with Ignition System."

Popping in Carbureter. Snapping or popping in the carbureter is caused by lack of gasoline, so that the mixture fed to the motor is not rich enough, and as a result it burns so slowly that one of the admission valves may be open before the charge is completely burned, and part of the burning charge is forced back through the pipe leading from the carbureter to the combustion chambers. If adjustment of carbureter is such that a weak mixture should not occur, inspect

the gasoline piping system carefully for an obstruction. Popping in the carbureter may also be caused by a leaky joint in the piping and connections between the carbureter and the combustion chambers.

Poor Compression. Valve stem may be broken and sticking. Valve spring or valve stem may be clogged with dirt. Cylinder or explosion chamber may be cracked. Piston rings may be broken or turned so that cuts line up, allowing pressure to escape. Cylinder may be gummed. Cam may be loose. Water may leak into cylinder through plugs in cylinder head. Valves may not seat properly due to being covered with soot. Valves may have to be reground.

Engine Starts but Stops After a Few Revolutions. Engine bearings may have seized from lack of lubricant. There may be too much oil in crank case. Water may be entering cylinder through cracks or through plugs in cylinder head. Carbureter float may be sticking. Poor water circulation may be due to broken pump shaft or clogged water piping.

Engine Runs Well on Slow Speed but not on High Speed. Muffler may be stopped up. Carbureter air valve not properly adjusted.

Engine Pulls on High Speed but not on Low Speed. There may be a leak in the inlet pipe. Carbureter adjustment not proper.

Knocking Continues Even After Spark is Properly Adjusted. There is a possibility of the flywheel being loose, of loose or worn bearings in the engine, or of something broken inside the engine.

TROUBLES WITH COOLING SYSTEM

Anti-freezing Solutions. The following are satisfactory formulae for anti-freezing mixtures:

1. *Mix equal parts of glycerine and water. Replace evaporation with clean water. Replace leakage with fresh solution.*

2. *Mix equal parts of denatured alcohol and water. Replace evaporation with alcohol and replace leakage with solution.*

Radiators. Radiators must be kept well filled. Leaky radiators are difficult to repair. This work should be done by an experienced radiator man, never by a plumber.

Soft Water. Soft water should be used for filling tank. It should be borne in mind that the circulating water gets pretty hot and incrustation may result from hard water.

Engine Heats, Loses Power, and Knocks. These are all symp-

toms of lack of water circulation. To see if this is the case, look into the opening in the top of the radiator and see whether water is flowing in from the engine. If not, either the water piping system is stopped up, which can be checked by disconnecting, or else the circulating pump is not working properly. All modern engines are so proportioned that, in this event, the water continues to circulate by thermosiphon action. Taking off the pump will verify this.

TROUBLES WITH GASOLINE SYSTEM

Carbureters. Carbureters should be among the last things to change in case of trouble. A black smoke from the exhaust will indicate too rich a mixture. Too thin a mixture may cause backfiring through the carburetor.

Flooding of Carburetor. This may be due to the failure of the needle valve to seat properly, which may be corrected by grinding the valve; or to a punctured float which must be removed and the hole carefully soldered. It may also be due to the spraying nozzle being so adjusted that the opening is below the gasoline level. To remedy, raise the nozzle by easy steps until the correct level is obtained.

Filling of Gasoline Tank. This should never be done by lamp or lantern light.

Leaks in Gasoline Line. These must be repaired as soon as discovered. They may result in fire, destroying the car and endangering the lives of its occupants.

Filler Cap. The filler cap should uncover an opening in which is a strainer of gauze wire which should not be taken out, or if broken, should be replaced promptly. As an additional protection against small foreign particles getting into the gasoline system a funnel should be used in which a chamois skin is suspended through which the gasoline is poured.

Grade of Gasoline. For ordinary use gasoline from 56 to 68 degrees test is most satisfactory. The former, called also *stove gasoline*, is the only kind obtainable now.

Obstruction in Needle Valve in Carburetor. In searching for a clogged gasoline line, it is well to unscrew the needle of the needle valve and then blow through the valve. This will remove particles of dirt that may be there.

TROUBLES WITH IGNITION SYSTEM

Testing Batteries. Batteries are best tested by means of a pocket ammeter which will register the amperage at once and settle any questions as to whether or not any electrical trouble is due to weak batteries.

Care of Timer. The timer should be kept thoroughly lubricated with a light oil and should be cleaned with gasoline occasionally, after which the oil should be replenished.

Coil Contact Points. These sometimes become pitted. One will be an irregular sharp point, the other a pit. Adjusting under these conditions will do no good. Remove the knurled thumbscrew and with great care, using a fine key file, level or flatten the platinum contacts. Be careful to file no more than necessary as there is very little material to go on and new contacts are expensive. Replace thumbscrews and adjust with the lightest tension that will give good results.

Loose Electrical Connections. It is well to examine daily all wiring, battery connections, etc., to see that they are tight. Sometimes a broken wire will be found which will give trouble.

Missing Explosions. To test whether explosions are missing, press down on the muffler cut-out pedal. This will make the sound of each explosion more pronounced. Among the causes for missing explosions the following are most usual:

1. Spark plug dirty or short-circuited or cracked.
2. Loose electrical connections.
3. Weak batteries.
4. Timer contacts dirty or worn.
5. Coil contact points dirty or pitted or out of adjustment.
6. Carbureter out of adjustment.
7. Water in gasoline.

Extra Spark Plugs. Extra spark plugs should always be carried.

Vibrator Spring Tension. When the batteries are fresh, the vibrator spring is kept at a constant tension. However, if the batteries weaken, the spring tension will need to be decreased or new batteries substituted.

Cleaning Spark Plugs. With a brush and gasoline clean off grease and carbon taking the plug apart as far as possible. Use fine sand-paper or emery cloth to brighten porcelain, mica, etc.—for the

sparkling tips the emery cloth is the better. In reassembling plug see that the air gap is about $\frac{1}{8}$ ". Best results are obtained by having the air gaps uniform in each cylinder.

To Test Spark Plugs. Remove plug from cylinder. Connect it with wiring system, laying it on its side with metal part of plug in contact with the cylinder or other metal part of engine. Turn engine over and notice if spark occurs properly. If there is no spark with timer on contact turn off the current at switch and look for broken wire or loose or wrong connections. In addition, timing may be faulty.

Timer. The timer must not be in contact when car is standing still as the continual drain on the battery will soon put it out of business. Worn contacts on timer should be renewed. If dirty, clean thoroughly with gasoline and apply a little thin oil.

Weak Batteries. Weak batteries should be promptly replaced. It is a good plan to take out old cells one at a time, replacing with a new one in order that the connections and direction of travel of current may remain unchanged.

Spark Plugs Get Foul Every Day. This indicates either too much gasoline, too much cylinder oil, or poor quality of gasoline.

Explosions in Muffler. This is due to one or more cylinders missing, allowing the unexploded gasoline vapor to collect in the muffler, and can be traced to carbureter being set to give too much gasoline or it may be due to trouble with the sparking. Quite often it is due to a weak battery.

TROUBLES WITH LUBRICATION SYSTEM

Crank Case Oil. This should be changed about every 500 miles as by this time the lubricating qualities of the oil are nearly exhausted. After draining oil, wash out crank case with kerosene and see that the kerosene is removed before putting in fresh oil.

Grease Cups. These are usually located on rear axle, steering knuckles, steering column base, and many other parts. They should be kept constantly filled with cup grease. These grease cups should not be confused with small oil holes having caps, which can be raised but not unscrewed. Grease cups should be screwed down occasionally in order to force the grease down to the bearing surface.

Neglect of Lubrication. Neglect of lubrication is responsible

for many troubles. Any automobile requires careful attention to its lubricating system. The owner will find it to his advantage financially to see that all necessary parts are properly lubricated.

Steering Gear. The steering gear parts require occasional lubrication. These parts include steering rod, worm or sector and gear, steering link at both ends, foot pedal pivot or bearing, and all joints.

Too Much Oil in Crank Case. Usually drain cocks are provided in the crank case and are so located that when they are opened they will drain off only the surplus oil.

Troubles with Mechanical Lubricator. If one of the sight feeds fills with oil it indicates too rapid feeding of oil. Shut off the valve on the top of the lubricator till the glass is clear. If it does not clear up shortly the probability is that it is necessary to clean the lubricator.

Mixing Gas Engine Cylinder Oil with Fuel. This is advocated by the makers of a few two-cycle engines, the proportion being one-half pint of best gas engine cylinder oil with every five gallons of gasoline. This, however, is not considered good practice.

TROUBLES WITH CLUTCHES

Throwing in Clutch. Do not throw clutch in suddenly causing rear wheels to spin. Such action is destructive to tires and throws great stress on the entire mechanism of the car.

Lubricating Multiple Disk Clutches. These are best lubricated by injecting oil into the opening for that purpose by means of an oil gun. A very light lubricating oil should be used.

Multiple Disk Clutches Failing to Hold. Inject three or four gunfuls of kerosene into the clutch housing and run the engine a little, thereby washing out the plates of the clutch. This will cut the gum caused by the oil. If, after this treatment, the clutch squeaks or takes hold too suddenly, lubricating oil may be added.

Loss of Power. This is noticeable in changing from intermediate to high gear, in climbing hills, or in running through muddy or sandy roads. The trouble is often due to clutch slipping. The remedy is to clean the clutch with gasoline and if the clutch is leather-faced apply castor oil after cleaning. Castor oil should never be used on the multiple-disk clutch.

Failure of Clutch to Take Hold. This may be due to a broken or weakened clutch spring, the clutch leather may be damaged,

clutch shaft may be out of line or bent, leather may be gummed, or bearing may be seizing.

TROUBLES WITH TRANSMISSION SYSTEM

Lubricating Transmission Gears. Transmission case should be filled with lubricant to a depth of several inches. Care should be exercised at frequent intervals to see that a proper amount of lubricant remains in the transmission case. Different makers recommend different kinds of lubricants for transmissions. In light cars a mixture often used consists of equal proportions of light grease and machine oil. In heavier cars a heavy gravity grease is often used. The proper lubricant depends upon the types of bearings used; thus for ball-bearing transmissions, no oil need be added.

Change Speed Lever Indicates Some Impediment in Transmission. It is desirable to look for broken or mutilated gears, broken bearings in transmission shafts, sticking or misalignment of gear shafts or of their operating mechanisms.

Adjusting Annular Bearings. Makers recommend that the inner race be pinched so tight that movement is impossible; the outer race is sometimes allowed a little freedom — $\frac{1}{16}$ in. to $\frac{1}{8}$ in.

TROUBLES WITH DRIVE SYSTEM

Chains. When chains are removed for cleaning they should never be replaced in the same relation of sprocket teeth and chain links as before. This can be avoided by marking both sprocket and chain with a prick punch or scribe. The reason is that in the first position the chain has adapted itself to the sprocket and putting it back in a different way although causing some noise tends to equalize the wear instead of increasing it. The chain can be cleaned without taking off of sprockets by brushing with kerosene, and after this cleaning, oiling each link and allowing the oil to work into the rivet, and then wiping off all surplus oil.

Differential Housing. The differential housing on rear axle should be kept supplied with an abundance of cup grease.

Universal Joints. The universal joints should have the lubricant renewed every 1,000 miles or less, usually less. The lubricant commonly employed consists of grease.

Noisy Chains. Chains may be too tight, or sprockets out of line.



AUTOMOBILE TRUCK STRIPPED FOR REPAIR WITH GAS-WELDING O

Courtesy of Oxyweld-Acetylene Company, Chicago, Illinois



WELDING BROKEN FRAME OF AUTOMOBILE TRUCK

Courtesy of Oxyweld-Acetylene Company, Chicago, Illinois

the metals which cannot be welded by hammering. As a matter of fact, any process which causes cohesion between the molecules of the two pieces to be joined may rightfully be called welding. This excludes such processes as soldering or brazing, because in the latter cases a kind of metal different from the pieces joined is used to hold them together. Welding involves the use of metals of the same kind for the joint.

Conditions Favorable to Successful Welding. *Plasticity.* Metals are most easily welded when in a condition of plasticity just between the molten and the solid states; hence, those metals which remain plastic the longest after fusing are the easiest to weld. Iron, platinum, nickel, and gold have been hammer-welded for many years, but recent inventions have greatly extended the field, and now nearly all metals may be welded by some process. Even aluminum castings may be welded by both the gas and the electric arc processes and most of the alloys may also be welded successfully.

Flow, Cohesion, and Temperature. Successful welding by any process depends almost entirely upon three factors—flow, cohesion, and temperature. The metal must tend to flow when under pressure, even if to but a slight degree. The surfaces of the pieces to be welded must tend to “wet” each other and stick together, or cohere, to an appreciable extent when heated. The working temperature must be that at which the foregoing conditions are most prominent. The best welding condition for any metal exists within a limited range of temperature only, hence it is very important that the operator should know how each kind of metal acts when fused and welded by the various processes now in use. This can be learned only by study and experience, but it is fully worth while because the demand for good welding operators is increasing faster than the supply.

WELDING PROCESSES

Classification of Methods. There are several processes of joining metals, but there are only four kinds of welding processes in use—smith or forge welding, sometimes called blacksmith welding; electric welding, including contact and arc welding; gas or hot-flame welding; and chemical welding. For automobile repairs, electric arc and gas welding are used almost entirely because of

their convenience, simplicity, and economy. In order that the student may be informed regarding all of them, we will describe them here in a general way, and then give some detailed applications of the two most used in automobile repair shops.

Smith Welding. Smith welding, or forging, is the general process of forming or joining metals by hammering or pressing the pieces into the desired shape, and may be done either hot or cold, depending upon circumstances. When joining two pieces of metal, especially iron or steel, it is done hot and is one of the oldest of the useful arts. It is the most common of all welding processes, but depends more upon the skill of the operator than any other process of welding; on this account, and because it is also rather expensive and slow, it is gradually being superseded.

Electric Welding. Electric welding was used as a laboratory experiment for a number of years, but recently the process has been developed to such an extent that it is rapidly coming to the front as the most important of all welding processes. Two distinct methods have been perfected, the one used for automobile repairs being based upon utilizing the heat of the electric arc to fuse metals into place. The other process provides for the passage of a heavy current through the joint between the pieces, allowing the resistance of the bad contact to heat the pieces until they are soft enough to stick together; squeezing the pieces while soft will then cause them to stick. This process is used mostly in making automobile parts—such as mud guards, bonnets, etc.—rather than for repairs. The electric arc-welding process will be described in detail later.

Gas Welding. Gas welding, or hot-flame welding, is at present used to a greater extent in automobile repair shops than any other system of welding, because the first cost of the equipments is comparatively small and also because acetylene headlights were formerly used on automobiles and gas was very easily obtained. The system is very good for most operations, and there are now three important processes in commercial use, known as the *oxy-acetylene*, *oxy-hydrogen*, and *blau gas* processes. The *oxy-acetylene* and *oxy-hydrogen* processes are the ones used in America almost exclusively and will be described in detail later. They all consist in using oxygen and another gas to give a flame of sufficiently high temperature and

heating capacity to melt the material to be welded, the gas used with the oxygen being indicated by the name of the process. In all cases the oxygen and the other gas under pressure are mixed in the burner chamber in suitable proportions, and when ignited form a very hot flame. This is directed on the work in such a way as to cause the metals to fuse and flow together. When no extra material is added to form the weld, it is said to be autogenous or self-forming, and this expression also applies to electric arc welding when done with the graphite electrode.

Chemical Welding. Chemical welding is exemplified today almost exclusively by the process known as "Thermit Welding", and consists of igniting a mixture of oxide of iron and aluminum so as to set up a chemical reaction which evolves an intense heat. A suitable mold must be constructed about the joint to be welded, and the operation carried out in such a way as to form a heavy reinforcement at the joint. This really forms a *cast-weld* and is very effective in places where it can be used, but the process is usually limited to jobs of comparatively large size because of the cost. For this reason it is not used for automobile repairs to such an extent as the other processes mentioned.

METHODS OF PRE-HEATING

Necessity of Pre-Heating. For a great many welding operations it is necessary to heat the parts to a bright red heat before starting the welding, especially in the case of cast-iron engine cylinders, etc., when machining is to be done on the pieces at the weld. Unless the parts are carefully pre-heated they will be too hard to machine, and are liable to crack when cooling. For smith welding it is necessary to heat most metals to the point where they almost begin to flow before they can be welded. This is especially true of iron and steel, both of which are used extensively in automobile construction.

Production of Temperature. The combustion of fuel—either coal, coke, oil, or charcoal—causes the oxygen of the air to combine with the carbon of the fuel, and this chemical combination is what produces heat. The *amount* of heat depends upon the amount of carbon and oxygen combined during combustion, whereas the *temperature* attained depends entirely upon the rapidity with which

the combination takes place. This is one of the most important facts to be learned in connection with welding, because the principle involved applies to all systems of welding.

Torches and Forges. Torches are most commonly used for heating when the work cannot be easily moved; they are designed to use gas, oil, or gasoline, either with or without compressed air to assist in combustion. Forges are the most economical means of producing heat when they can be used, burning coal, coke, or charcoal—the latter giving the best results because it is free from

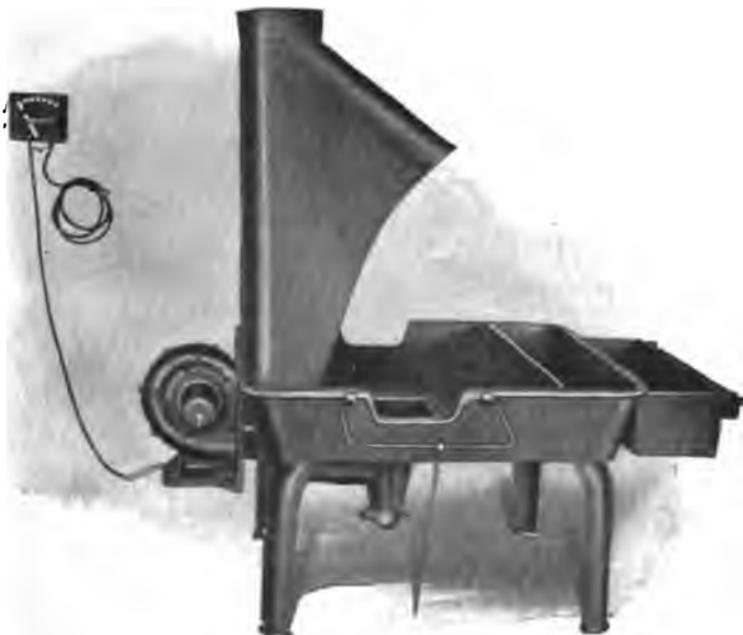


Fig. 1. Modern Motor-Driven Forge
Courtesy of Canedy-Otto Company

impurities. The coal and coke used must be free from sulphur and phosphorus, for sulphur makes iron *hot-short*, or brittle, when hot, and phosphorus makes it *cold-short*, or brittle, when cold. Both of these elements will be absorbed by the metal when hot. Copper, lead, tin, and other non-ferrous metals should be kept out of the fire as they will spoil iron or steel for welding.

Forced Draft. Under ordinary conditions, combustion alone would not be rapid enough to generate the amount of heat or temperature required for welding, so a forced draft is created through the fire or flame in order to supply sufficient oxygen to the fuel and

increase the rate of combustion. Too much air will chill the fire, or perhaps blow it out, and an excess of oxygen will cause some of it to combine with the iron and form a scale of oxide of iron. This latter is called an *oxidizing fire*; whereas, if the oxygen is all consumed in the fire and there is an excess of carbon, it is then called a *reducing fire*. When welding with oxy-acetylene or oxy-hydrogen flames, it is also important that the proportions between the gases be properly maintained to prevent the formation of oxidizing or reducing flames.

Where the draft is provided by means of a forge, Fig. 1, the work may be laid on the fire and fuel piled up around it, if the article is small. If it is a large piece, it will usually be necessary

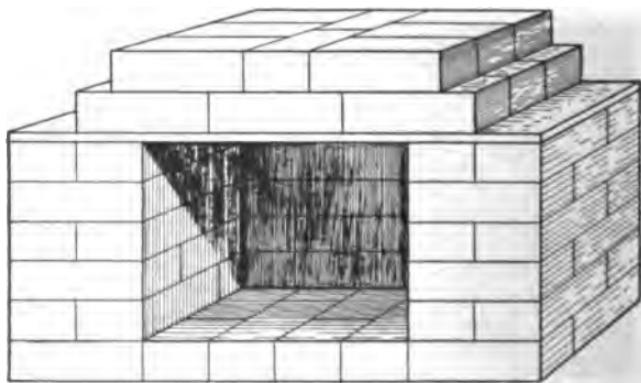


Fig. 2. Temporary Brick Furnace for Pre-Heating Work

to construct a temporary furnace with a few fire bricks, Fig. 2, and to build a good charcoal fire therein; but care should be taken to prevent overheating the piece. If torches are to be used, it will usually be best to also build a temporary furnace in which the piece can be placed, with arrangements to allow a torch to be placed each side of the furnace with the flames directed into it and on the piece.

Facilities for Handling Pieces and Keeping Them Hot. Some suitable means should also be provided for handling the hot articles so that they can be placed on the work table for welding; or a portion of the furnace should be quickly removable to give access to the piece as it lies in place. Work should be done while the piece is as hot as possible, and the furnace again closed to allow the piece

to cool slowly. If the piece is welded outside of the furnace, some suitable non-heat-conducting material, such as ashes or flake asbestos, should be piled around the article to keep in the heat and cause slow cooling. Welds made on iron castings treated in this manner should be as soft as the original casting.

When heating articles to be welded, care should be taken to consider the shape of the piece and to heat it in such a way that it will not expand unequally and cause cracking at some other place. If this is done right, it will not be necessary to heat the entire piece, thus saving a great amount of time in many instances. This is especially true when the article is of *closed shape*, such as a spoked wheel or gear.

ELECTRIC ARC WELDING

The Electric Arc. The use of the electric arc as a source of heat is one of the oldest applications of electricity, both for cutting metals and for fusing them together, but until a comparatively few years ago it was done on only a small scale. The electric arc has been given a great amount of study, and yet very little is known about its most important characteristics. The exact temperature of the arc is not known, but this is estimated at about 4000 degrees centigrade (7200 Fahrenheit, approximately), because it will melt all known substances. This makes it a very efficient source of heat and indicates why electric arc welding is the process that is so rapidly coming to the front for all purposes.

About seventy-five years ago it was discovered that the electric current will flow more easily from metal to carbon than in the reverse direction; it was also found that the current through an arc is greater when passing from an easily oxidized metal to one that is less so, than when flowing in the opposite direction. This is easily understood, because the conductivity of an arc depends largely upon the kind of vapor in the arc, and to some extent upon the ease with which the welding electrode can be kept at a high temperature. In the arc-welding systems in use today, the arc is drawn between metal and carbon or between metal and metal. Since the positive electrode, or terminal, of an arc reaches a higher temperature than the negative electrode, or terminal, it is more efficient to use the article worked upon as the positive electrode

of the arc. This is done by attaching to the job the line, or wire, from the positive side of the machine.

Since iron or steel are more easily vaporized than carbon, the current flows more easily from iron to carbon than the reverse because there is more iron vapor than carbon vapor in the arc. This is also proved by the fact that it requires more voltage to send a given current through an arc between carbons than between metal electrodes. It is also important that the negative electrode be kept at a high temperature, and the usual practice of having the negative electrode small (due to the use of a wire or of a carbon pencil) makes this easily possible.

Arc-Welding Process. The process of welding or cutting with the electric arc is possible with nothing more than a source of current at a suitable voltage, some means for regulating the amount of current flowing, and an electrode. However, the work done with such a crude system will not be satisfactory nor commercially acceptable, so certain other devices are necessary to insure a first-class job. In order to do welding or cutting with the electric arc, after suitable equipment has been provided, it is necessary to first connect the *work* to the positive side of the power supply circuit and the welding electrode to the negative side of the circuit, by means of wires or cables, with the regulating devices in circuit to control the amount of current flowing. The negative electrode should then be placed lightly in contact with the work, Fig. 3, and quickly withdrawn to make the circuit and draw the arc, thus providing the high temperature required for welding. The metal will begin to melt immediately and work may then proceed until finished.

Electric arc welding usually consists in using the heat of the arc to fuse or melt the filling material into the place to be filled, although the article worked upon may be melted down sufficiently to fill the space if it is large enough at the point to be welded. Two methods or processes of using the arc for welding are in commercial use today, these being the *metallic* and the *graphite*, or *carbon*, processes. The metallic welding process consists in using a piece of wire of the proper kind as the negative electrode of the arc and fusing it into place drop by drop; the graphite process consists in using a piece of graphite, or carbon, as the negative electrode and fusing a piece of metal into place by the heat of the arc, similar to a gas

process. The graphite process is always used for cutting, a slot being melted through the piece to be separated; this is a very economical method for this purpose. Further reference to these processes will be made when describing their applications.

Arc-Welding Equipment. General Features. The equipment required for electric arc welding in automobile repair shops will depend largely upon the kind and amount of work to be done,



Fig. 3. Operator Using Metallic Electrode
Courtesy of C & C Electric and Manufacturing Company
Garwood, New Jersey

but the most complete equipment allows of the best work the same as with any other sort of apparatus. The use of resistances only, as the means of regulating the amount of current flowing, is very wasteful, so other apparatus must be used for the sake of economy. It is well known among electrical men that a motor-generator set gives the best regulation of voltage, therefore, the leading welding outfits in use today consist of motor-generator sets with suitable control apparatus for motor, generator, and welding circuits. Fig. 4 shows a typical wiring diagram for an arc-welding outfit, and it will be seen that the switchboard contains all of the instruments

required for controlling the machine, and also the resistance switch for regulating the amount of current flowing through the arc. The connections are very simple and the operation and care of the apparatus are easily learned by any good mechanic.

There are several companies manufacturing electric arc-welding outfits suitable for automobile repairs, each company offering its apparatus on the strength of some peculiarity of the machines or devices for their control. In all cases the equipment furnished consists of the welding machine proper and its control panel, face shields for the operators to protect their eyes from the bright arc,

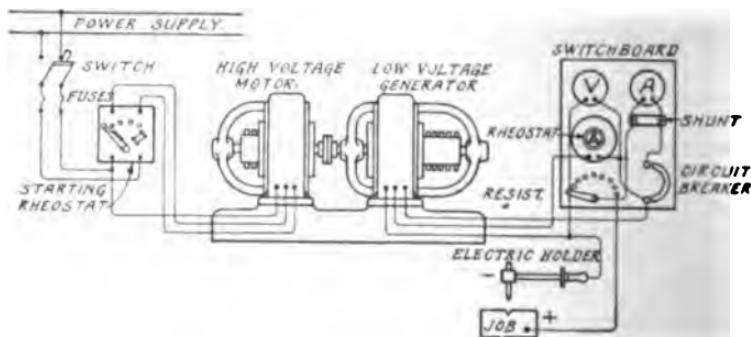


Fig. 4. Standard Layout and Connections for Low-Voltage Motor-Generator Welding Outfit

and suitable electrode holders with cables. Full instructions for the installing and use of the apparatus are also given, and in some cases expert demonstrators are sent out to instruct the users in the best methods of performing various operations. For welding broken engine cylinder castings it will require an outfit of 300 to 400 amperes capacity, and the same size is required for cutting, Fig. 5. A machine of this capacity will be large enough for two men on steel work, and outfits up to 1200 amperes capacity can be obtained where several men are required to work at once. For most automobile repair shops, however, a single-circuit machine for one operator will be sufficient, having a capacity of 150 to 200 amperes at about 50 volts, Fig. 6. With such an outfit it is possible to weld main frames, cross-members, steel crank cases, broken crankshafts, mud guards, steel bodies, bonnets, brake parts, valve stems, cam-shafts, driving shafts, broken gear teeth, rear axle housings, steel rims and hubs, etc.

Portable Sets. When conditions require work to be done



Fig. 5. 300-Ampere Welding Set with Control Panel and Auxiliary Welding Panels
Courtesy of C & C Electric and Manufacturing Company, Garwood, New Jersey



Fig. 6. Arc-Welding Set with Automatic Overload Relay
Courtesy of General Electric Company

outside of the shop, as in case of accidents or when the motor car cannot be brought to the shop to have the work done, portable equipments will be found very useful. A portable outfit is shown in Fig. 7, for use when a direct current is available at the place where the work is to be done, and consists of the dynamotor, or welding machine, on a steel truck with the control panel containing the machine and welding control attachments. Fig. 8 shows a gasoline engine-driven welding generator which can be set upon a

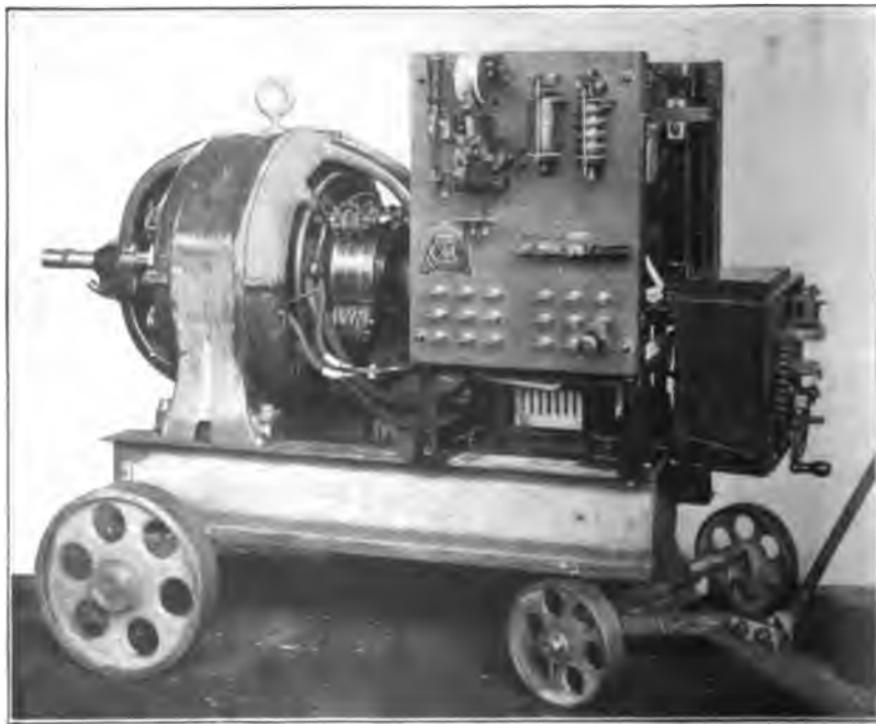


Fig. 7. Portable Arc-Welding Outfit
Courtesy of C & C Electric and Manufacturing Company, Garwood, New Jersey

motor truck and taken anywhere; its control panel will be similar to the one shown in Fig. 7. Machines of these types are made in one-, two-, or three-man sizes and can be made to pay handsome profits. A machine of either type can also be used in the shop when not out on emergency repair work, and can be used for other things than automobile work during the dull seasons.

Current Required for Welding. Welding operations are of various kinds and take differing amounts of current, depending

AUTOMOBILE WELDING



upon the nature of the material worked upon, the size and shape of the piece, and the sort of operation to be performed. For example: thin sheets of steel require less current than thick ones; cutting requires more current than welding; and heavy forgings demand different treatment from castings, etc. As a general rule it may be said that metallic electrode welding takes from 40 to 160 amperes, although thin sheets may be welded with as little as 15 amperes and heavy ones may demand up to 195 amperes. Graphite arc welding averages from 300 to 500 amperes, running from 100 amperes on small articles up to 700 amperes on heavy work. Cutting with the graphite electrode arc requires from 300 amperes on small sections up to 1000 amperes or more on large pieces, the usual limits being between 400 and 600 amperes. Articles such as side frames, rear axles, and housings are welded with the metallic electrode and take from 130 to 160 amperes, using a $\frac{3}{16}$ -inch diameter wire. Cast-iron cylinder castings require from 300 to 400 amperes for cutting out and preparing, and about the same for welding. They should also be carefully pre-heated before welding; further reference will be made to the handling of cylinder castings. When work is properly done by the electric arc process, it should be as strong as the original piece.

GAS OR HOT-FLAME WELDING

Definition of Process. Hot-flame or gas welding consists primarily in joining metals by fusing them together at the place desired through the use of a high temperature gas flame as the source of heat. Several combinations of gases are now in use for this purpose and new types of apparatus are continually appearing on the market, based upon the use of some special feature or gas. There are two methods of gas welding in general use, the *autogenous* and the *heterogeneous*,¹ the names indicating the difference. The word autogenous signifies that the weld is made by the fusion, or joining, of the parts without the use of additional metal, whereas the word heterogeneous—meaning a *mixture*, signifies that the weld is made by fusing-in additional material to complete the weld. The term autogenous has unfortunately come to be applied to all forms of gas welding, and some confusion has resulted because the statement is often made that neither fluxes nor hammering

are necessary with that process; actually, a flux is at times beneficial for some metals, and hammering will help the strength of joint in certain other cases.

Classification of Processes. Oxygen and hydrogen were probably the first gases used for welding, and most of the systems of gas welding in use today use oxygen in combination with some other gas, the processes taking their names from the particular combination used. The leading welding processes are known as the "Oxy-Acetylene", "Oxy-Hydrogen" (or "Oxy-Hydric"), "Oxy-Pintsch Gas", "Blau Gas", "Water-Gas", and "Coal-Gas", the use of Pintsch gas (same as is used in lighting railroad trains) with oxygen being the latest development. All of these depend upon the use of compressed gases, usually stored in strong cylinders and mixed in the burner or torch as used; these may be used for either welding or cutting.

Types of Outfits. Large repair shops using considerable gas have stationary plants for the generation of acetylene and buy their oxygen, while the plants using the oxy-hydrogen and other processes usually buy all of their gases. These come in cylinders, compressed so as to give large supplies in small spaces. Small portable outfits are made with the two gas cylinders on a truck, as shown in Fig. 9, but the larger plants are permanently installed, as shown in Fig. 10. Where large quantities of oxygen are required, it is economical to install special generators for it.

Gases Used for Welding. *Acetylene.* Acetylene (C_2H_2) is a colorless gas with a very disagreeable odor—very largely due to the impurities present in it—and is obtained almost exclusively



Fig. 9. Portable Welding or Cutting Oxy-Acetylene Unit

Courtesy of Daris-Bournonville Company

from calcium carbide and water. Great care must be used to see that pure carbide is used in order to prevent the generation of phosphureted-hydrogen along with the acetylene. Calcium carbide (CaC_2) is a dark gray slag, formed by fusing lime and coke in the intense heat of the electric furnace; it possesses a great affinity for water. When it is combined with water (H_2O), in the proportion of 2 parts water to 1 part calcium carbide, a chemical reaction takes



Fig. 10. 100-Pound Oxy-Acetylene Welding Outfit
Courtesy of Daris-Bourneville Company

place which heats the mass and forms acetylene gas (C_2H_2) and lime (CaOH_2O) in the form of ashes. In other words, the carbon combines with the hydrogen to form acetylene and the calcium combines with the oxygen to form lime. One pound of carbide will yield about $4\frac{1}{2}$ cubic feet of acetylene gas.

Hydrogen. Hydrogen (H_2) is one of the elements and is the lightest substance known. It is obtained by the decomposition of water into its elements, oxygen and hydrogen, both gases being

collected and used. Hydrogen is also sometimes prepared by passing steam over coke that has been heated to a dull red, but electrochemical processes are so much better that they are gradually superseding all others. If the temperature is not too high, when using the hot coke process, carbon dioxide and hydrogen will be formed ($C+2H_2O=2H_2+CO_2$), but the carbon dioxide may be removed by passing the gas through a vessel of slaked lime. Hydrogen is explosive when mixed with air or oxygen, and when oxygen and hydrogen are mixed in a suitable burner for welding or cutting they produce a temperature of about $2500^{\circ} C$. Hydrogen is not poisonous, but may cause death if inhaled because it will exclude oxygen from the lungs.

Oxygen. Oxygen (O) is the most important of all of the elements known to man, and is used as one of the gases in nearly all welding processes of the hot-flame type. Oxygen is produced commercially (1) from the air by liquefaction and fractional distillation; (2) from water by electrolytic action; and (3) from potassium chlorate by heating. The production of oxygen from air by liquefaction is still the greatest source of supply for it today, but recent developments and improvements in electrolytic apparatus have added greatly to the source of supply and reduced the cost in many cases where electric power is cheap and plentiful. Oxygen should be free from chlorine to be suitable for welding, although the usual mixture of 5 per cent of nitrogen and 2 per cent to 3 per cent of hydrogen is no disadvantage. Its production is not a very complicated process but the apparatus is quite expensive, and only those plants requiring 1000 cubic feet or more per week can afford to make their own oxygen. It is sold in tanks containing 5, 25, 50, or 100 cubic feet under high pressure, as desired, and the tanks may be either bought or rented and only the gas paid for. The tanks can be recharged when empty, and each tank is equipped with a reducing valve to regulate the pressure when using. A pressure gage must also be used, and leakage must be looked out for on account of the high pressure (300 pounds per square inch).

Miscellaneous Gases. The three gases just described are the only ones used to any extent in automobile repair shops, so that only brief descriptions of the others will be given. *Pintsch gas* is made from crude petroleum or similar oils and will safely stand a

high degree of compression. It can be obtained in flasks at pressures from 180 pounds per square inch up to 1500 pounds per square inch but is used at about 25 pounds per square inch, with oxygen, for welding. *Coal gas*, or illuminating gas, is produced by the distillation of coal by heating in a closed retort. One ton of coal will produce about 10,000 cubic feet of gas, 1400 pounds of coke, 12 gallons of tar, and 4 pounds of ammonia, the operation lasting about 4 hours. Coal gas is used only for welding metals of low melting point and has largely been superseded by other gases. *Blau gas* is really liquefied illuminating gas and is produced by the distillation of certain mineral oils in hot retorts; it is not poisonous. It is sold in cylinders at pressures of about 1500 pounds and is coming into increased use in this country. *Water gas* is a mixture of carbon monoxide and hydrogen and is formed by passing steam over or through incandescent coke, similar to the production of oxygen, thus causing the steam to decompose into oxygen and hydrogen. The oxygen combines with the carbon from the coke and forms carbon monoxide, with a little carbon dioxide and a few easily removed impurities. Thirty-five pounds of coke are used for each 1000 cubic feet of gas. Water gas burns at a very high temperature, but is dangerous if it escapes because it is odorless.

Gas-Welding Processes. The *oxy-acetylene* and the *oxy-hydrogen* processes are used more in automobile repair shops than all others combined, so these will be considered in detail. The oxy-hydrogen welding process is the oldest of the gas-welding systems, but the oxy-acetylene process is better known because there are more people making such apparatus and more outfits in use, so that process will be considered first.

Oxy-Acetylene Process. The oxy-acetylene process is based upon the use or combustion of oxygen and acetylene at the tip of a suitable torch to produce the heat required for fusing metals, the temperature being about 3500 degrees centigrade. The operation of welding with gas is similar to that already described in connection with electric arc welding with the graphite electrode, as the flame is the source of heat and the filling material must be added as melted. The flame is played against the metal until it becomes hot enough to fuse, both the job and the filler being melted to insure a homogeneous joint. The torch should be given a sort

of rotary motion around over the surface of the weld, with a slightly forward and upward movement, in order to blend the metal and reduce the liability to overheat it.

Adjusting the Flame. The operator must first learn to adjust his flame to suit his work, but there is no rule for the exact proportions of oxygen and acetylene so it is not easy to learn. It can be learned by practice, however, if there is no instructor available, as the proportion of gases is about $1\frac{1}{2}$ parts oxygen to 1 part acetylene for most purposes. If the oxygen is as great as 2.5 to 1 of acetylene, an oxidizing flame will be produced, which will probably cut the metal; if there is too much acetylene, it will split up or *crack* and allow carbon to enter the weld and carbonize it or make it hard. The flame should be adjusted so that the two cones formed in the flame unite into a single small one, and the tip of the white cone in the flame should just touch the metal. The hand must be held steady when working because if the tip of the torch should touch the work, it might cause a *flash back* and necessitate relighting; if not, an explosion or something worse might happen.

Oxy-Hydrogen Process. Oxy-hydrogen torches are handled similarly to oxy-acetylene torches, but when lighting it is necessary to turn the hydrogen on about two-thirds of the way and light it first. The oxygen should then be turned on enough to give a pale blue conical flame, and then the hydrogen should be turned on full. This will take but a few seconds and should give a temperature of about 2800 degrees centigrade. The end of the cone of oxygen in the flame should never touch the work, as this would probably burn it. When through work, the oxygen should be turned off first. Theoretically, 2 parts of hydrogen should be used for each part of oxygen but experience shows that it is desirable to use as much as 3 parts of hydrogen in many cases to prevent burning of the metal. A larger proportion of hydrogen is not necessary if the two gases are properly mixed in the burner.

Gas-Welding Apparatus. General Features. The apparatus required for oxy-acetylene or oxy-hydrogen welding and cutting is very similar, consisting in either case of a supply of the gases; a suitable burner or torch; regulating valves; and hose for the connections. Beyond this, the differences are in details of the equipment only. Under the descriptions of the gases used for

welding we have already learned something of the processes for their production and storage, but the gas generators are sufficiently different to warrant some further description.

Acetylene Equipment. The acetylene generator is a comparatively simple device, usually a single steel receptacle with compartments for holding the water, carbide, and gas, with various attachments for controlling its action. High-pressure systems are gradually being abandoned, and today the medium- and low-pressure systems only are in much use, with the low-pressure system of generation in the majority. After the gas is generated, however, it is compressed and stored at very high pressures. The best known system of acetylene storage and distribution is that of the Prest-O-Lite Company of Indianapolis, which consists of cylinders which can be bought or rented filled with acetylene ready for use.

Acetylene is readily soluble in liquid acetone, which is cheap, inert, and incombustible; so storage cylinders are partly filled with it and the acetylene gas compressed into it. Owing to its peculiar nature, acetone will dissolve 24 times its own volume of acetylene at atmospheric pressure and at a temperature of 15 degrees centigrade. At 12 times atmospheric pressure (180 pounds), it will dissolve about 300 times its volume of acetylene, and expand only about 50 per cent when doing so. The cylinders are partly filled with asbestos fiber to carry the acetone, and it is merely necessary to charge them with compressed acetylene to fill them. When the necessary valves and gages are attached, the cylinders are ready for use, and when accompanied by similar cylinders filled with compressed oxygen and mounted on small trucks, as shown in Fig. 9, form good portable welding outfits for use in garages.

Acetylene generators are made in five types, of which the *drop* type is most used. It is the most economical, and is arranged so that the carbide is fed into a hopper at the top and falls a few lumps at a time into a large vessel of water below. The carbide is not so good ground as it is in lumps, and the feeding mechanism is operated by the gas pressure in order to keep the supply constant. The water absorbs the heat generated by the chemical action, thus keeping the gas and the outfit cooler than with some of the other types. The gas bubbles up through the water and is washed, the lime remaining in the bottom where it can be reached for removal; this lime can

be used as a fertilizer. Theoretically, 1 pound of carbide requires $\frac{1}{2}$ pound of water to make gas, but in practice it takes about 1 gallon of water to 1 pound of carbide for the best results. This should produce about $4\frac{1}{2}$ cubic feet of gas, with a loss of only about 3 per cent by absorption in the water. The attachments on the generator tank are usually a filter, flash-back chamber, drainage chamber, water filling tube, blow-off valve, and other devices required for connections, etc. Calcium carbide alone is not an explosive and will not explode when heated, but it will absorb moisture very rapidly and generate acetylene which is explosive and must, therefore, be kept in air-tight cans. Acetylene is explosive at any point between the limits of 2 per cent gas and 98 per cent air up to 49 per cent gas and 51 per cent air, so must be handled carefully.

Oxygen and Hydrogen Manufacture. Oxygen generators are quite expensive and complicated, so it is best to buy compressed oxygen in cylinders instead of trying to make it unless the quantity required is very great. The same thing applies to hydrogen, but since they are both produced from water by the electrolytic process it will be worth while to consider the apparatus in a general way here. This process consists in passing a direct current of electricity at 2 or 3 volts pressure through a solution of sodium or potassium chlorate in water as the electrolyte, which produces 2 volumes of hydrogen to 1 of oxygen. Since a direct current is used, oxygen arises from the water around the positive terminal and hydrogen from around the negative plate, each gas being conducted through separate pipes for compression and storage. The equipment usually consists of several generators in the form of tanks of cast iron, with a partition extending part way down in the center to divide the tank into two parts. One terminal is placed in each section and the temperature maintained at about 165 degrees Fahrenheit, because the work can be done at a lower voltage at this temperature than at any other. From 240 to 325 amperes of current are used, and the gases are about 99 per cent pure when made by this process. Purity is very important, because foreign matter in the gas may cause it to burn or spoil the weld. The apparatus for producing oxygen by the liquefaction of air is quite complicated and will not be discussed here; the other chemical processes are so little used they can be omitted also.

Torches. The torches or blow-pipes for gas welding, Fig. 11, and cutting, Fig. 12, are very important, and it was due to their imperfect development that prevented gas welding from being used a great many years ago. In general, torches for any system



Fig. 11. Typical Gas-Welding Torch
Courtesy of Oxyweld-Acetylene Company, Chicago, Illinois



Fig. 12. Typical Gas-Cutting Torch
Courtesy of Oxyweld-Acetylene Company, Chicago, Illinois

consist of a head or mixing chamber into which a suitable renewable tip can be screwed; two tubes to lead the gases to the head before mixing; valves for regulating the proportion of each gas; connections for the hose leading from the storage tanks; and a suitable handle for the torch. The torches are made as small and light as possible without sacrificing strength or safety, in order that the operator will not tire too easily through their use, and the hose should be

small and flexible for the same reason. Wire gauze is placed inside the torch to prevent the gases flashing back in case of too low pressure, and the tips are of various sizes to suit different kinds of work. Goggles for the operator's eyes and gloves for the hands are also necessary.

WELDING OPERATIONS

Work to Be Done. A great many automobile repair shops are merely a part of a garage catering to people who desire to store their cars and purchase supplies, and such shops are not equipped to do more than the simplest of repair jobs and make adjustments. Shops desiring to do any sort of work which may come in must have the proper kind of equipment, and it is such shops that require welding apparatus of some sort. The work to be done will vary from welding a cracked side frame without dismantling, or a broken spring shackle, or steering knuckle, up to saving a cracked cylinder or crank case, welding a broken crank shaft, or other job requiring dismantling, or even practically rebuilding a car which has been almost ruined through a general smash-up. It is really astonishing to see how much can be done in shops having complete and up-to-date welding apparatus, and comparatively large amounts can be saved for owners while at the same time making large profits for the shops by such work. About the only thing it does not pay to repair is a broken wire spoke in a wheel, if proper apparatus is available.

Qualities Required of Men. *Qualities of Skill and Judgment.* The art of welding with either gas or electric arc welding apparatus can be learned by most any good mechanic of average intelligence if he is sufficiently interested in his work to really want to become an artist, but it cannot be learned any quicker than any other line of work. Under the direction of an experienced instructor it will in most cases be possible to learn how to handle the torch or electrode holder and to apply the welding material to the joint within a week or two. After that it is a matter of several months of steady practice before the operator will become really proficient and be able to handle any sort of a job that comes along. This does not mean that welding is too hard for an average good mechanic to learn, but merely that it is not so simple as it appears after watch-

ing an expert do the work. In addition to learning how to handle the flame or arc and get the right heat, it is necessary to know how to fuse the various metals without burning them; flow them into place without having them run away; work the filler and the metal of the job together so as to form a homogeneous weld; know when and when not to use flux; when to pre-heat; how to weld so as not to get hard spots in the work; and how to handle the work so it will not crack in cooling. It is also necessary to learn what jobs it will not pay to try to weld and when it will be best to use the gas or the electric arc for the work.

Ingenuity. The expert welder will never admit that a job cannot be welded unless he knows it will not pay to spend the time and money required to do it. One of the principal requirements in a good welder is ingenuity, because there will be many times when a little careful planning will make it worth while to do a job which otherwise might be considered impracticable from the financial standpoint. For example, if the broken article is a low priced piece and is in bad condition it will be better to replace it than to try to save it—unless the car owner is in a hurry and a new part is not available—whereas, if the piece is large or complicated and expensive to replace it will nearly always pay to weld it. An ingenious operator will soon learn to decide such matters quickly, develop new methods, reduce costs, and thus build up a good reputation for his shop which will result in increased business at good prices.

All-Around Mechanical Training. There is no special kind of mechanical training that will fit a man for welding any better than any other kind, but as a sort of general rule it may safely be said that a good all around mechanic will probably be better equipped than any man who knows but one branch of his trade. The man who has had at least a little experience as a blacksmith, machinist, boiler maker, foundryman, engineer, and electrician is better equipped than a man who has had less experience, providing he has really learned something from his experience instead of being merely a restless wanderer from shop to shop. He should also have a good knowledge of the construction and operation of automobiles and other machinery, and also of the strength of materials and their proper uses and limitations.

Equipment Required. Requirements in Small and Large Shops.

Small repair shops or garages limiting themselves to the lighter kinds of jobs can get along with a comparatively small gas welding outfit of any reliable make; but larger shops should have electric arc welders, and the largest or most complete establishments must have both arc and gas welders to be really properly equipped to do all kinds of work most rapidly, economically, and conveniently. It will then be possible to use the process best suited to each job, or to do several jobs of different kinds at the same time. It is also desirable to have capacity for at least two men to work at once, no matter what system of welding is used, because large numbers of jobs can be done better if done quickly.

Equipment Best Suited to Various Classes of Work. Small gas welders are good for welding light sheet steel, copper, brass, or aluminum, or small castings of the same metals. Small arc welders are better suited for medium and heavy steel plates, forgings, castings, and for other kinds of general welding work. Large gas welders are best for cutting, but may be used for medium or heavy welding work when the cost of operation is of no importance. Medium or large sized arc welders will be found best for heavy work, cast-iron welding, or in shops requiring more than two or three operators, and may also be used for cutting. Electric arc welding is cheaper than gas welding for nearly everything excepting comparatively thin sheet steel work and for articles of brass or bronze. Gas welders are cheaper to operate for light steel plates and for most of the cutting jobs to be done in automobile repair shops. Occasional exceptions to the above rules will be found, but in general they will hold to be true. This accounts for the rapidly increasing adoption of arc welders in automobile factories as well as repair shops.

Small Equipment. In general, as has already been stated, iron and steel plates, castings, and forgings can best be welded with the electric arc, but non-ferrous metals like brass, copper, aluminum, platinum, gold, silver, etc., can best be welded with gas, hence it is preferable to have both kinds of equipment available, even though one of them be small. In addition to the welding machines it will be necessary to have the usual attachments and supplies, such as torches and hose, goggles, etc., which are a part

of all gas outfits; and the electrode holders and cables, face shields, etc., which come with arc outfits. Gloves of good buckskin are also desirable, and a kit of tools consisting of hammer, chisel, coarse and fine files, screw clamps of two to three sizes, pliers, hack saw, rule, and piece of chalk and waste will also be required. The tool kit will be increased in size as the operator becomes more experienced and has a great variety of work to do, but the foregoing will be a good start.

In the shop there should be a good forge, or a couple of medium or large sized torches for pre-heating large pieces before welding. This is especially true when preparing cast iron for welding and will be referred to later when discussing cylinder repairs. Vises on substantial benches; two or three pairs of strong "horses"; a good emery wheel; a separate space to work in, and plenty of good light are also essential to the best work. The space where arc welding is to be done should be screened off from the rest of the shop if a separate room is not available, because the arc is brighter than a gas flame, but if ordinary common sense is used there is no danger from the arc as has been claimed. The face shields, Fig. 3, will give all the protection required for the operators, and there are men using the arc who have done so for over 25 years with entire safety. Any additional equipment beyond that above enumerated will be valuable, of course, and a well equipped machine shop should also be available nearby (if not in the shop) so that many of the parts repaired can be machined before using, if necessary. This will always be necessary when repairing finished surfaces, such as the tops of crank cases, cylinder bases or lugs, shafts, etc.

Kinds of Fillers to Use. As a general rule, it may safely be stated that the materials used in welding by any process should be similar to that composing the article to be welded. There are but few exceptions to this rule, the principal one being that it usually pays to use a filler containing an excess of those elements which pass off at high temperatures or which may be necessary to give added strength to the weld, if needed. In all cases it will pay to use only pure materials and the best obtainable regardless of cost, because a poor weld may not only have to be done over at a loss but may also injure the reputation of the shop doing it. There

are several companies specializing in the supply of welding materials, and in the best shops it is the rule to have everything tested or analyzed before accepting it or using it.

Effect of Various Substances in Welding Material. Some reference has already been made to the effect of impurities in iron, under the heading "Methods of Pre-Heating", but a few more words as to certain other conditions are also necessary. *Carbon* increases the tensile or pulling strength of iron, but it also decreases its elongation or stretching before breaking and should be kept as small in amount as possible in welding wire. Carbon also tends to cause crystallization of steel under repeated shocks or vibration, and also when heated and cooled frequently, with consequent liability to become brittle and easily broken. *Sulphur* is a very common impurity in welding materials and must be looked out for because it makes the metal brittle when hot, and causes it to crack easily if hammered while hot. *Phosphorus* causes large crystals to form in the weld when cooling, thus reducing the strength and making it break easier when cold. This has the reverse effect from sulphur and they both should be eliminated. *Slag* is also found in low grade welding materials and makes good, clean, reliable or homogeneous welds impossible. These impurities are not found in the best grades of genuine imported Swedish iron wire, hence this has become the universal welding material for all kinds of iron and steel plates, forgings, etc., and for many kinds of steel casting welding.

Preparation of Work. Before starting the welding operation proper, it is necessary to be sure that the piece is properly prepared to receive the filling material, that the parts are properly aligned, and that the weld can be carried through to a satisfactory conclusion.

Small Pieces. Pieces of comparatively light section, such as *steel plate*, etc., of not more than $\frac{1}{8}$ inch in thickness, may be welded by leaving a space between them of somewhat less than their thickness and filling in with metal by using the gas or metallic arc welders. If the sheets lie face to face and require welding along the edges, it will be sufficient to clamp them tightly and fuse down the edges with the gas or the carbon arc, or in some cases deposit metal with the metallic arc. If the plates are over $\frac{1}{8}$ inch thick it will be necessary to bevel the edges of the joint to an angle of 30° to 60° , depend-

ing upon the thickness, in order to provide space enough for the filler. An average case will require beveling each side to an angle of about 45° for butt welding the sheets edge to edge, and this will also apply to such parts as side frames, also.

Large Pieces. Large pieces, such as *forgings*, *castings*, etc., must always be beveled sufficiently to insure making the weld the full thickness of the piece, and the amount of bevel should be great enough to allow plenty of room for easy work in order to keep down the cost of handling. When possible to work from both sides of the piece, beveling should be done on both sides before starting welding, thus reducing the amount of space required and the amount of filling to be done. *Steel forgings* need not be pre-heated if welded with the arc using the metallic electrode, but it is preferable to pre-heat if the work must be done with gas on account of the cost of gas used in bringing the piece up to welding heat. The same thing applies to *steel castings* of medium or small size, but large steel castings or *cast-iron* pieces should always be pre-heated before welding by any process. This not only reduces the time required to get the temperature up to the proper point for welding but also insures the piece being soft enough to machine after welding, and reduces the liability to crack when cooling after welding. It is also desirable to keep the piece hot while welding, so work must sometimes be done with the piece in a forge or temporary furnace, especially large iron castings. This is not very pleasant for the operator, but such jobs are usually of short duration.

Copper Alloys. Castings of any of the *copper alloys*, such as *brass*, *bronze*, etc., are best welded with gas, but require similar preparation to articles of iron or steel. Cracks or other joints should be beveled to allow access to the bottom of the space to be welded, and medium or large pieces must be pre-heated to reduce welding cost and time. Copper is a good conductor of heat, so it is usually necessary to heat the part quite thoroughly in order to insure a good weld. These materials may also be welded with the arc by using a graphite electrode, and in all cases the filler should be of the same composition as the piece. The principal difficulty met with in welding brass and other articles containing zinc, lead, and tin is that these elements burn out at a comparatively low temperature and leave the weld spongy or porous, consequently.

especial care must be used to keep the heat as low as it can be and still fuse the metal. This is the principal reason for using gas instead of the arc for such materials, because the arc is so hot.

Aluminum. Aluminum castings can be welded with either kind of apparatus, and the parts need not be beveled unless they are over $\frac{1}{4}$ inch thick because the metal must be fused with the flame, and only enough pure aluminum added to make up the losses and give a slight reinforcement to the weld. *Sheet aluminum* should be welded with gas, and the joint need not be beveled, but great care must be taken to prevent burning the metal.

Welding Materials for Filler. As already stated under the heading of "Equipment Required", the filling material should usually be of the same composition as the material to be welded, but it will be well to consider that matter in more detail at this point and before starting to describe the various operations usually arising in automobile repair shops. For welding plates of iron or steel it is best to use pure iron, such as *Swedish iron*, or *Norway iron* (so called), as it will amalgamate or mix with the job and give a good weld practically every time. *Alloy steels* of various kinds, such as vanadium steel, manganese steel, chrome steel, nickel steel, etc., have been welded with similar materials but not with any very great degree of success. This is due to the fact that the metals used as alloys burn out at the welding temperature and leave the weld porous, or lie inert in the form of globules and spoil the weld. The same thing is true when trying to weld *bronze alloys*, such as phosphor-bronze, manganese bronze, etc., so it is quite important that the operator be sure of his metal before starting to weld it by any process. *High carbon steel* may be welded if the piece is not to be subjected to great strains because the material next to the weld will be weakened by the operation, but it will be all right in some cases where the metal has been used to give good wearing life if the weld is not made on the wearing surface.

For welding articles of *cast iron* it is best to use new material, cast-iron rods containing about 2 or 3 per cent excess of silicon being best for this purpose, because they produce good grey iron in the weld and make machining easier if properly pre-heated. If the iron contains as much as 4 per cent of silicon, it will be even better for large jobs, because the silicon is reduced under the action

of the flame or arc. The presence of manganese is not desirable for cast-iron welding, and good flux should always be used if the castings are not of the very best grade. Gasoline engine cylinders are usually made of good grey iron, but even there it is well to use powdered aluminum as a flux to insure good welds. Scrap material seldom makes a good weld, even for articles of *brass* or *bronze*, because you can never be sure of its composition. A small amount of aluminum will be helpful for welding *copper alloys*, and sometimes a little phosphorus will help, but it should be put into the welding rods by foundries knowing their business or trouble will usually follow. To successfully weld *copper* requires a filler with enough phosphorus to completely de-oxidize the weld, because copper-oxide forms very rapidly at the welding temperature of copper. When properly done, the weld should be invisible and of the same color as the rest of the copper, but unless the operator has had considerable experience with his welding apparatus it is better to braze copper and brass if possible. *Aluminum* should be welded with pure aluminum, free from silicon, and new metal is necessary.

DETAILS OF SPECIAL WELDS

After learning the preceding matter, the student desiring to become an expert welder by either the gas or arc processes must then practice in the use of the apparatus in order to apply the principles, because after learning to use the apparatus the work has only begun. It is only by months of continuous practice at the work that any man can become really expert and able to do any sort of work which may come along. The action of the various metals under the action of the high temperature welding process is of the utmost importance, because similar pieces may act differently on account of the weather, drafts in the room, location on the automobile, variations in composition, welding process used, speed with which the work must be done, etc. So we will consider a series of typical repair jobs in detail, and determine the best procedure in each case.

Welding Main Frames. With the exception of the "Franklin" car, automobile main frames are made of steel channels, either structural channels on trucks or steel plate pressed into channel form of irregular shape for pleasure cars. These channels vary from about $\frac{1}{2}$ inch thick up to nearly $\frac{3}{4}$ inch thick, and from 3 inches

deep up to 8 inches deep with flanges top and bottom, and should be treated in very much the same way as steel plates of similar thicknesses. That is, the crack should be chipped out on one side to form a groove into which the filler may be fused. Work will usually have to be done from one side only, because the job is in a hurry or there is too much dismantling required, and it is best to work from the outside of the frame if possible. The paint should be scraped off for about an inch each side of the joint and all grease wiped off with a little gasoline before starting work, otherwise



Fig. 13. Welding Broken Frame of 5-Ton Automobile Truck with a Gas Torch
Courtesy of Oxweld-Acetylene Company, Chicago, Illinois

it might get into the weld and spoil the work. Since most cracks or breaks occur in the side frames, instead of in the cross-braces, the work will generally have to be done by working against the vertical surface and the metallic arc welder is easier to use than gas, but gas may be used, as shown in Fig. 13, and the filler fused in if the operator is careful and starts work at the bottom and works upward.

If the frame has started to crack from below, the first thing to do is to jack it up to bring the parts in line and close up the crack. Then chip it out as described so as to weld full thickness of the



Fig. 14. Damaged Frame of Automobile Truck
Courtesy of Orweld-Acetylene Company, Chicago, Illinois



Fig. 15. Truck Frame of Fig. 14 Repaired by Gas-Welding Outfit,
Unengaged Parts Protected by Asbestos Paper
Courtesy of Orweld-Acetylene Company, Chicago, Illinois

flange and web of the angle, and deposit enough metal to reinforce the stock until about double the original thickness. Chip, grind, or file smooth and paint. The reinforcement should be left on unless necessary to attach something at the point of repair. If the break comes at a hole in the frame, such as where a spring shackle is attached, it is usually best to weld the hole up and re-drill it. If some part has been torn off accidentally and made a large hole in the frame, a piece can be set in and welded all around the edges to tie it to the frame. Figs. 14 and 15 show a truck frame with

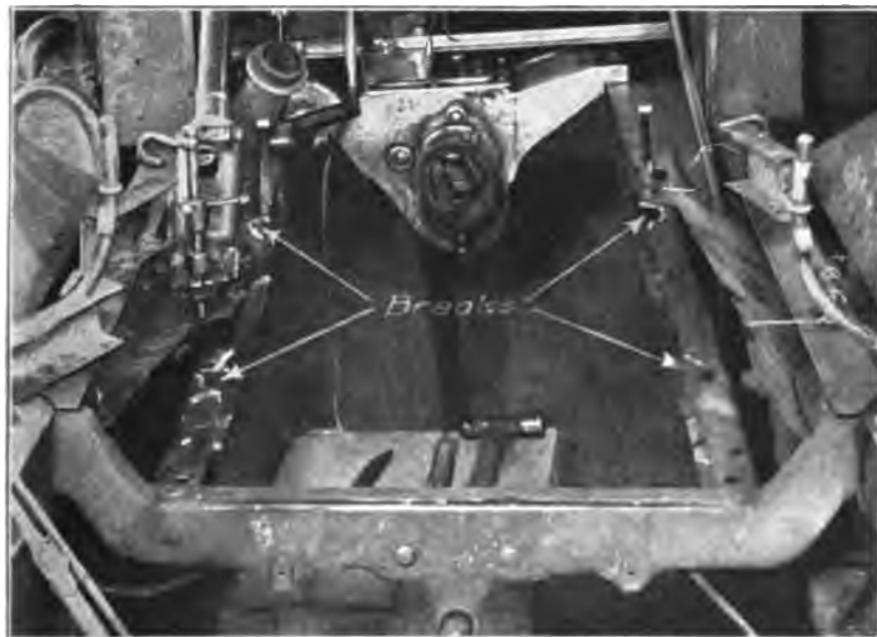


Fig. 16. Broken Touring Car Chassis Ready for Welds
Courtesy of C & C Electric and Manufacturing Company, Garwood, New Jersey

a piece broken out of one corner and a new piece welded in place with oxy-hydrogen apparatus, made by the Oxweld-Acetylene Company, Chicago, Illinois.

Sometimes a frame will break entirely through full depth, due to an accident or too heavy loading, and in such cases it will be best to weld a channel-shaped reinforcing piece inside and tie the frame to it at the point of break. In this case, the new piece should be welded along the edges of both flanges and at the ends, and also through holes at intervals to tie the two pieces together as completely

as possible. When the flanges are broken it is also best to set a piece on the inside, and Fig. 16 shows a touring car that had the engine torn out accidentally in such a way as to rip pieces out of the flanges on both side frames. Channel shaped steel pieces were set inside the frames and welded in with the metallic electrode, the breaks in the flanges filled in flush and new holes drilled. Fig. 17 shows the finished job ready for drilling engine bracket holes, and a job of this sort can be done in about a half day at a cost for labor, material, and electric power of \$2.00 to \$3.00, depend-

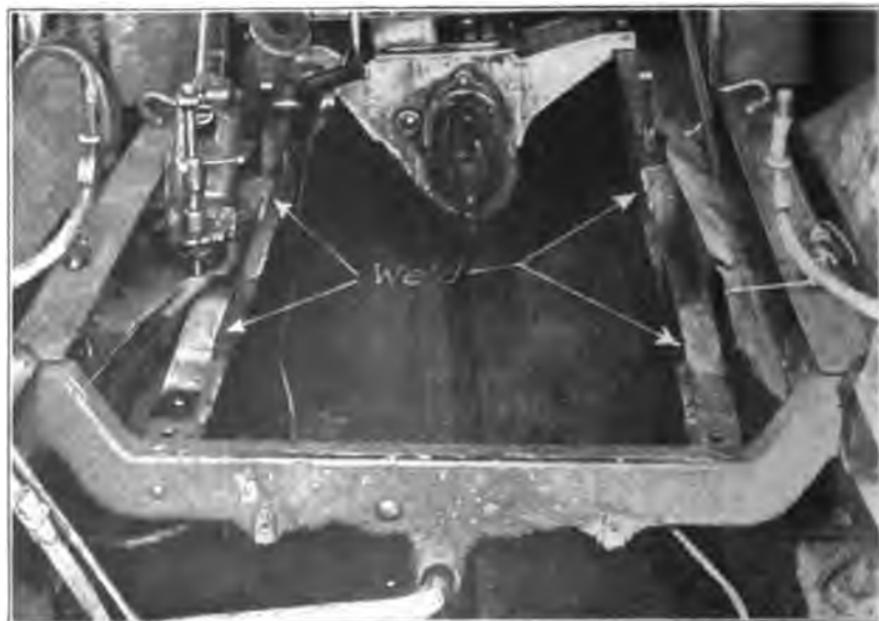


Fig. 17. Frame of Fig. 16 Repaired by Electric Welding Outfit
Courtesy of C & C Electric and Manufacturing Company, Garwood, New Jersey

ing upon the cost of current. The usual charge for this work is from \$10.00 to \$15.00, whereas a new frame will cost in place \$50.00 to \$75.00 on account of the labor of dismantling and assembling everything on the car. A similar job done with gas will cost from \$4.00 to \$6.00 in most shops.

Welding Running Gear. Rear Axles and Housings. The running gear of an automobile usually gets a large share of abuse, so any weaknesses are bound to develop there in a short time if they exist. Rear axle housings are now made in various ways of pressed steel parts welded together, and if the work is not well

done or the parts too light there will be trouble. If the entire housing breaks in two, as indicated in Fig. 18, it must be lined up and clamped in position, chipped out along the crack to get room for welding and then filled in with enough reinforcement to insure the required strength, Fig. 19. This is a rare happening and is



Fig. 18. Broken Rear Axle Housing
Courtesy of Oxweld-Acetylene Company, Chicago, Illinois

usually the result of a bad smash-up, but where the housings are not properly welded along the edges, as shown in Fig. 20, there is considerable liability of the seam opening up under the vibration met with in service. In such cases it is necessary to chip out the joint full length and re-weld. This sort of job has been done with the greatest success by using the metallic electrode arc welding process, using a $\frac{1}{8}$ inch wire and about 120 amperes and depositing



Fig. 19. Rear Axle Housing of Fig. 18 Repaired by Gas Weld
Courtesy of Oxweld-Acetylene Company, Chicago, Illinois

the joint full, as shown in Fig. 21. The work will be smooth enough to paint over, and such a job should not cost over \$1.00, although the charge to customer would be \$3.00 to \$5.00.

Front Axles. Front axles are usually of steel forgings and seldom break, but in such an event they are easily welded because

steel is one of the easiest metals to weld. The pieces should be ground or chipped each side of the break and on each side of the piece to give two grooves in which to weld, and may be welded with either gas or the metallic arc. If the axle is out of the car, gas will be all right; but if in position on the car, the arc will probably



Fig. 20. Open Seam and Cracks in Welded Housing



Fig. 21. Housing of Fig. 21 Properly Welded by C & C outfit

be more convenient and consequently cheaper to use. This is another kind of job where it will be best to build up metal at the weld in order to give added strength, because the filling material will probably not be so strong as the original forging. Vanadium steel wire should be good for this purpose, although Swedish iron wire



Fig. 24. Eighteen Forgings Electrically Welded at Total Cost of \$105 for Labor, Current, and Material
Courtesy of C. & C. Electric and Manufacturing Company, Garwood, New Jersey

out in case of an emergency, but of course will not be so elastic as before. It pays to try it, however, in many cases because a large number of the breaks occur at the center of the spring where it rests on the axle, and this makes it possible to add a plate below to help stiffen the spring. Welded springs sometimes give as good service as new ones, so it is worth trying. The work is done in similar manner to any other steel plate welding. Steel rims have also been welded by both the gas and arc processes and are very successful. Similarly, small tubing in connection with the water

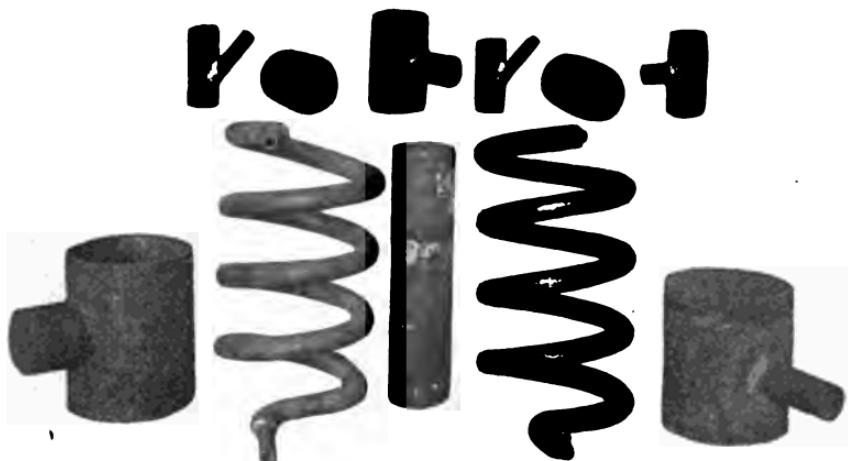


Fig. 25. Miscellaneous Pipe Welds with Light Tubing
Courtesy of C & C Electric and Manufacturing Company, Garwood, New Jersey

circulating system similar to the samples shown in Fig. 25 can be welded successfully.

Welding Crank Cases. *Aluminum Crank Cases.* Under this heading would naturally be included the engine crank cases, of iron, steel, or aluminum, and transmission cases. Aluminum crank cases are usually of castings and have been welded by both the gas and arc processes, but the gas process seems to give the best results on account of the ability to control the heat easier. However, great care must be taken to be sure the metal is not oxidized by the flame and ruined. The arc does not tend to oxidize so much and is being used more than formerly on that account, as well as the lower cost in most towns. The edges of the break must be carefully cleaned, and chipped if the part is over $\frac{1}{8}$ inch thick, Fig. 26, and the new pure aluminum fused into place, Fig. 27. The

flame or graphite arc, whichever is used, must be handled so as to fuse the metal each side of the weld into place with the new metal or there will be no joining of the filler with the metal of the piece. Since this is really a sort of "puddling" process, it is necessary to have the piece in a horizontal position where working in



Fig. 26. Broken Aluminum Crank Case
Courtesy of Oxweld-Acetylene Company, Chicago, Illinois

order to keep the molten metal from running out of the joint. In most cases it will be advisable to build up a mold or dam around the joint to hold the metal in place, and this can be of clay or other luting for gas welding but should be of powdered graphite mixed with silicate of soda (water-glass) for arc welding. The metallic



Fig. 27. Aluminum Crank Case of Fig. 26 Welded by Gas Outfit
Courtesy of Oxweld-Acetylene Company, Chicago, Illinois

electrode cannot be used for welding aluminum. Work of this sort is not cheaply done and usually the charges are in proportion to the value of the piece saved by welding.

Cast-Iron Crank Cases. Cast-iron crank cases or transmission cases can be welded as easily as any other cast-iron piece, but must

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Cast-Iron Crank Cases. Cast-iron crank cases or transmission cases can be welded as easily as any other cast-iron piece, but

this sort can be welded for about two cents, exclusive of the cost of preparation of the parts, or a total of about 50 cents, and are worth \$1.50 each.



Fig. 30. Broken Zinc Cylinder Casting with jacket Cut Away
A. Knowl-Edge, Inc.
Courtesy of U.S. Welding Company, Chicago, Illinois.

Welding Engine Cylinders. *Snagging the Break.* One of the commonest jobs arising in automobile repair shops is the welding of cracked engine cylinders, especially in the winter when people are careless about allowing their cooling water to freeze and crack the water-jacket. These cracks may be in the cylinder heads and

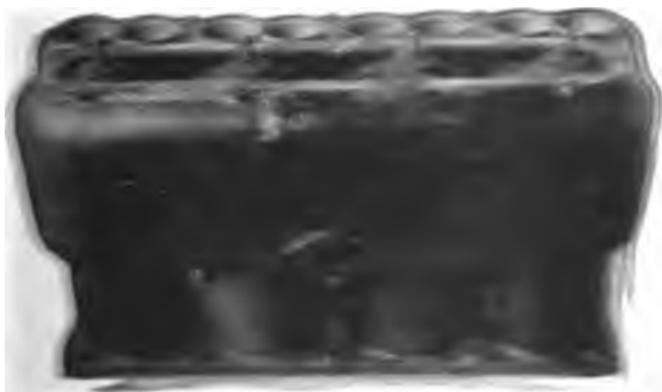


Fig. 31. Cylinder Casting with jacket Broken and Cut Away
Welded Back on
Courtesy of U.S. Welding Company, Chicago, Illinois.

necessitate cutting away a part of the jacket, Figs. 30 and 31, to give access to the break, or they may merely appear on the outer wall of the jacket and be easily handled. If the crack is on the

inner side it will be necessary to cut away the outer wall with an oxy-acetylene torch, weld the crack, and then re-weld the outer patch in place again. In such a case it will be necessary to examine the casting carefully to see where the parting ribs come inside of the water jacket, both with relation to the crack and to the various openings and bosses on the outside, before it will be safe to start work. Then the smallest hole possible should be cut in the outer wall of the jacket through which to work, and the edges of the crack chipped and cleaned ready for filling in. The entire casting should then be carefully and slowly pre-heated to a dull red heat in a good forge or furnace, with a fairly bright red heat at the point to be welded. The work can then be done with a gas torch or with the graphite electrode arc by puddling in new cast iron containing a little extra silicon, as already described, and must be done in a horizontal position. The patch can then be welded in the outside in a similar manner, and the casting allowed to cool slowly by being covered up with some good heat insulator or left in the furnace until it all cools off.

Block Cylinders. When handling single cylinders the job is comparatively easy, but in these days of block castings it is not so easy to do welding without the most complete equipment one can afford. These large and complicated castings require great care and careful consideration, but can be welded successfully and at considerable profit if handled right. Here is where a man with a little foundry experience will be able to go about his work a lot more freely than a man with no knowledge of how castings act when at a bright red heat. Iron cylinder castings should be annealed at the foundry when made, or before machining at the factory, and should therefore not be drawn out of shape by the pre-heating process when welding. If it is found that the casting is warped by pre-heating, the only thing to do is to get a new one. If the job is one which looks bad to do, or the shape and size of the casting are such as to cause any doubts regarding the success of the operation, it is best to explain the matter fully to the customer and undertake the job only at the customer's risk. In most cases, however, it will be safe to undertake the repair and no trouble should ensue if the work is properly done. Where the job consists of welding on a broken lug or foot it is comparatively easy, and after chipping or

grinding the edges of the joint the casting should be heated around the spot to be welded and then filled in. Care should always be taken to see that the lugs line up properly with the rest of the casting, if there is any finish on the parts or something is to be attached to them, and a slight reinforcement should be added if possible.

Costs. The cost of welding cylinders ranges from \$1.00 to \$3.00 for cracks in the outer walls of water jackets, when done by either process, and the charges run from \$2.00 to \$5.00 for the work. When the crack is through the inner wall, the cost is from \$3.00 to \$10.00, depending upon the kind of casting and size and location of crack, and the charge should be from \$5.00 to \$20.00, according to the value of a new casting and the amount of dismantling required, etc. In most instances the work will cost somewhat less when done with the graphite electrode, in towns where current costs not more than 3 cents per kilowatt hour, than when done by the gas process. Welding on lugs costs from 25 cents up to \$1.00 and brings from \$1.00 to \$5.00, depending upon circumstances. The matter of charges for work done on engine cylinders is a big problem, because the amount of work done in addition to the mere welding operation may be very much greater than that in connection with the weld alone, and this will frequently be of more importance in determining the price than the cost of the weld. If it is necessary to re-bore the cylinder, the charge must be in proportion.

Welding Body Parts. The tendency to return to the use of sheet aluminum for touring cars, limousines, runabouts, and other kinds of bodies, may result in calls upon repair shops to weld such materials, and it can be done with gas-welding outfits. Most cars now in service, however, have their bodies made of sheet steel and this may be welded with either the gas or the metallic electrode process. Where the framework of the body is of steel angles, the sheets can be welded thereto in place of riveting and a very good job done, but if the framing is of wood the only thing to be done is to weld the joints in the sheets. Welding done on bodies will always spoil the paint for a considerable distance around the weld, and if the plate is heated too much it will wrinkle. Electric arc welding presents some advantages over the gas for this work on that account, because the arc is localized when using the metallic electrode and the work is done so quickly and the arc moved along to another

spot before the heat can spread very far around the weld. It is also easier to work against vertical surfaces or overhead with the metallic electrode, although this is being done with gas-welding apparatus successfully now.



Fig. 32. Electric Arc-Welded Gasoline Storage Tank

materials, and gears should be welded like other forgings, Fig. 25. A gasoline storage tank with electrically welded seams is shown in Fig. 32.

Mud guards frequently come to grief against the sides of garage doors, other automobiles, wagons, etc., and require welding, and this can be done as easily as any other sheet-metal work. It is not necessary to bevel such thin material, although the paint should be removed from near the joint; by placing a block of steel along the upper surface and welding from the other side with a metallic electrode, the finished surface can be left in such smooth condition as to require very little finishing before painting. If the brackets supporting the guards are broken, they can be welded as readily as any other forgings, and this operation has been described. The bonnets can be handled as other sheet-metal parts, and leaky radiators should be soldered as usual as it does not pay to try to weld them. Piping of iron or steel, such as exhaust manifolds and pipes, mufflers, etc., are readily welded according to the principles already laid down for other parts of similar

GENERAL WELDING DATA

Sources of Information. In addition to the general information given in the foregoing pages regarding the applications of the various systems of welding, it will be necessary for the student of this subject to know various other facts in order to be fully informed on the matter. In addition to Tables I to VI, it will be well for the beginner to get copies of catalogues from the makers of the different

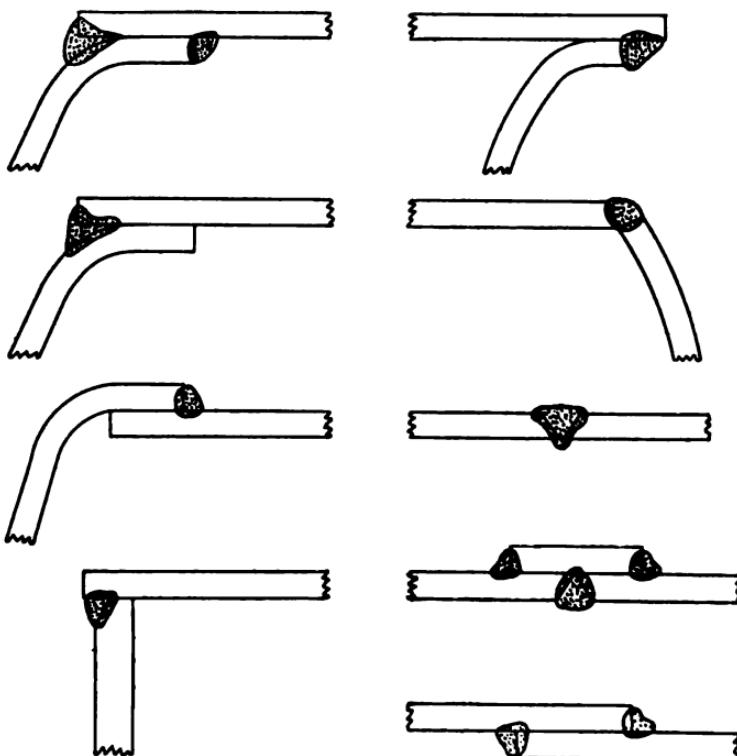


Fig. 33. Methods of Making Welded Seams in Tanks

Courtesy of C & C Electric and Manufacturing Company, Garwood, New Jersey

kinds of welding equipments and become familiar with the details of the apparatus and learn all the main facts given as to the uses of the devices. After starting to use any sort of a welder it will be wise to write to the makers occasionally and ask questions concerning difficulties arising in the course of the work. If it is not possible to do this, then write direct to us and we will help you in any way we can to solve your problems.

Strength of Welds. Unless a weld is strong enough for its purpose, it is a failure and represents a loss of time and money, so it is important to know what to expect when starting a job in order to put on a reinforcement if necessary. It is well known that a casting is not so strong as a forging or plate of the same material,



Fig. 34. Welded Steel Plates, Showing Strength of Welds
Courtesy of C & C Electric and Manufacturing
Company, Garwood, New Jersey

hence, when a weld is made, it will not be so strong as the original piece unless made larger in section. Welds made in steel plates can be made nearly as strong as the plate, the rule being to get from 90 per cent to 95 per cent of the original strength at the same thickness, and the relative strength will be greater for thin plates than for heavy ones. This is due to the fact that thin plates can be welded by going along the seam once only, whereas thick plates require going over the seam several times to fill in and this increases

the liability of slag forming in the weld or imperfect fusion taking place with consequent reduction of value. The plate welds shown in Fig. 33 show how the seams are handled in tank work.

In order to determine the relative strength of butt welded joints made with the arc using metallic electrodes, a series of plates, Fig. 34, were tested with the following results. Plates welded with gas would probably show similar results, and the relative costs would be about as given in Table I.

TABLE I
Strength of Butt-Welded Joints

PLATE THICKNESS (in.)	ELASTIC LIMIT (lb. per sq. in.)	TENSILE STRENGTH (lb. per sq. in.)	ELONGATION (per cent in 8 in.)	EFFICIENCY (per cent)
$\frac{1}{2}$	40930	54650	04.5	97.6
	44930	53020	05.75	94.7
	40160	51280	04.75	91.6

The data in Table I was made from tests on plates with a nominal ultimate strength on 56,000 pounds per square inch on tensile pull, and is a fair example of what should be expected in ordinary cases. The elongation in the weld will always be less than in the original stock because the joint will be really a casting, but its ductility can often be improved by hammering before it cools enough to lose color.

The question of the relative values of various methods of forming joints is sometimes hard to answer, so another series of tests

TABLE II
Relative Strength of Joints

SAMPLES AND PREPARATION	BREAKING STRAIN (lb.)	LENGTH AFTER BREAKING (in.)	EFFICIENCY (per cent)
Original piece of steel plate	58,600	8.80	100.00
Lap joint, arc welded	54,800	8.94	93.5
Lap joint, riveted and welded	54,200	9.22	92.2
Butt joint, arc welded	47,800	8.28	81.6
Butt joint, acetylene welded	36,800	8.23	62.8
Lap joint, riveted only	35,000	59.7

was made to give something definite to go by and this result is shown in Table II. These figures are averages only, and experience shows considerable variation above and below these figures in many cases. The butt joints broke through the welds in both cases, the riveted plate broke through the rivet holes, and the others broke outside the welds entirely. For most purposes in automobile work a butt joint will be necessary, but a lap joint or one made with a plate each side will be stronger, although a butted joint with some reinforcement will usually be all right. In all cases a great deal will depend upon the care with which the work is done.

Effect on Composition of Welds with Arc and Gas. Something has already been said regarding the composition of the welding materials required for various purposes, and Table III will show the effect on steel plates when welded by both the gas and the electric arc processes.

TABLE III
Analysis of Welded Steel Plate

ELEMENTS	ELECTRICALLY WELDED		ACETYLENE WELDED	
	Unwelded Metal (per cent)	Welded Joint (per cent)	Unwelded Metal (per cent)	Welded Joint (per cent)
Silicon	0.009	0.003	0.009	0.002
Carbon	0.15	Trace	0.15	Trace
Sulphur	0.025	0.020	0.085	0.071
Phosphorus	0.068	0.043	0.068	0.067
Manganese	0.64	0.27	0.49	0.34
Iron (by difference)	99.108	99.664	99.198	99.520
Totals	100.000	100.000	100.000	100.000

It will be seen that the silicon is reduced by welding much more than the other contents, although all are reduced somewhat. The percentage of iron increases, due to the reduction of the other elements, but the actual amount is the same after as before welding. In both cases the carbon was practically entirely burned out, and the arc reduced the phosphorus more than the gas flame.

Costs of Welds by Arc and Gas Methods. The relative costs of gas and arc welding on steel plate work are about the same on

light metal, but the arc is somewhat cheaper on heavy work on account of the gas used in keeping the plates warmed up to the proper temperature. For small shops doing but little repair work the cost of the work is not so important as the first cost of the apparatus, and for them a small gas welder will be all right, but large shops working on something all of the time must consider the cost of operation instead of merely the first cost of apparatus. Tables IV and V give some reliable figures on both electric arc and gas welding, these figures being supplied by makers and users of both kinds of apparatus. In both cases the labor is figured at 30 cents per hour, electric power at 2 cents per kilowatt hour, acetylene at 1 cent per cubic foot, and oxygen at 3 cents per cubic foot.

TABLE IV
Time and Cost of Electric Arc Welding

METAL THICKNESS (in.)	AVERAGE CURRENT (amp.)	SIZE WIRE (in.)	AVERAGE SPEED (ft. per hour)	APPROX. COST PER FOOT
$\frac{1}{16}$	15 to 25	$\frac{1}{16}$	22	0.0175
$\frac{1}{16}$ to $\frac{1}{8}$	25 to 50	$\frac{3}{32}$	20	0.0225
$\frac{1}{8}$ to $\frac{1}{4}$	50 to 80	$\frac{5}{32}$	18	0.0275
$\frac{1}{4}$ to $\frac{1}{2}$	80 to 110	$\frac{7}{32}$	16	0.035
$\frac{1}{2}$ to $\frac{1}{4}$	110 to 130	$\frac{9}{32}$	14	0.0475
$\frac{1}{4}$ to $\frac{1}{2}$	130 to 150	$\frac{11}{32}$	11	0.075
$\frac{1}{2}$ to $\frac{1}{2}$	150 to 165	$\frac{13}{32}$	8	0.105
$\frac{1}{2}$ to $\frac{1}{2}$	165 to 185	$\frac{15}{32}$	6	0.14

TABLE V
Time and Cost of Oxy-Acetylene Welding

METAL THICKNESS	ACETYLENE PER HOUR (cu. ft.)	OXYGEN PER HOUR (cu. ft.)	AVERAGE SPEED (ft per hour)	APPROX. COST PER FOOT
$\frac{1}{16}$	2.7	3.5	40	0.0085
$\frac{1}{16}$ to $\frac{1}{8}$	4.5	5.7	32	0.0175
$\frac{1}{8}$ to $\frac{1}{4}$	7.5	9.7	25	0.0275
$\frac{1}{4}$ to $\frac{1}{2}$	10.5	13.0	19	0.05
$\frac{1}{4}$ to $\frac{1}{2}$	14.0	18.0	14	0.08
$\frac{1}{2}$ to $\frac{1}{2}$	18.0	23.0	10	0.12
$\frac{1}{2}$ to $\frac{1}{2}$	24.0	30.0	7	0.22
$\frac{1}{2}$ to $\frac{1}{2}$	32.0	42.0	5	0.375

Tables IV and V can be used with a fair degree of safety when figuring any sort of straight seam work, such as building gasoline

tanks, but do not include the cost of handling the pieces preparatory to welding. This is an item which will vary in different shops on account of the facilities available and the great differences in overhead expenses or fixed charges. For repair work the cost of getting ready may easily be more than the cost of doing the job, so experience alone must be the guide in making estimates on such work.

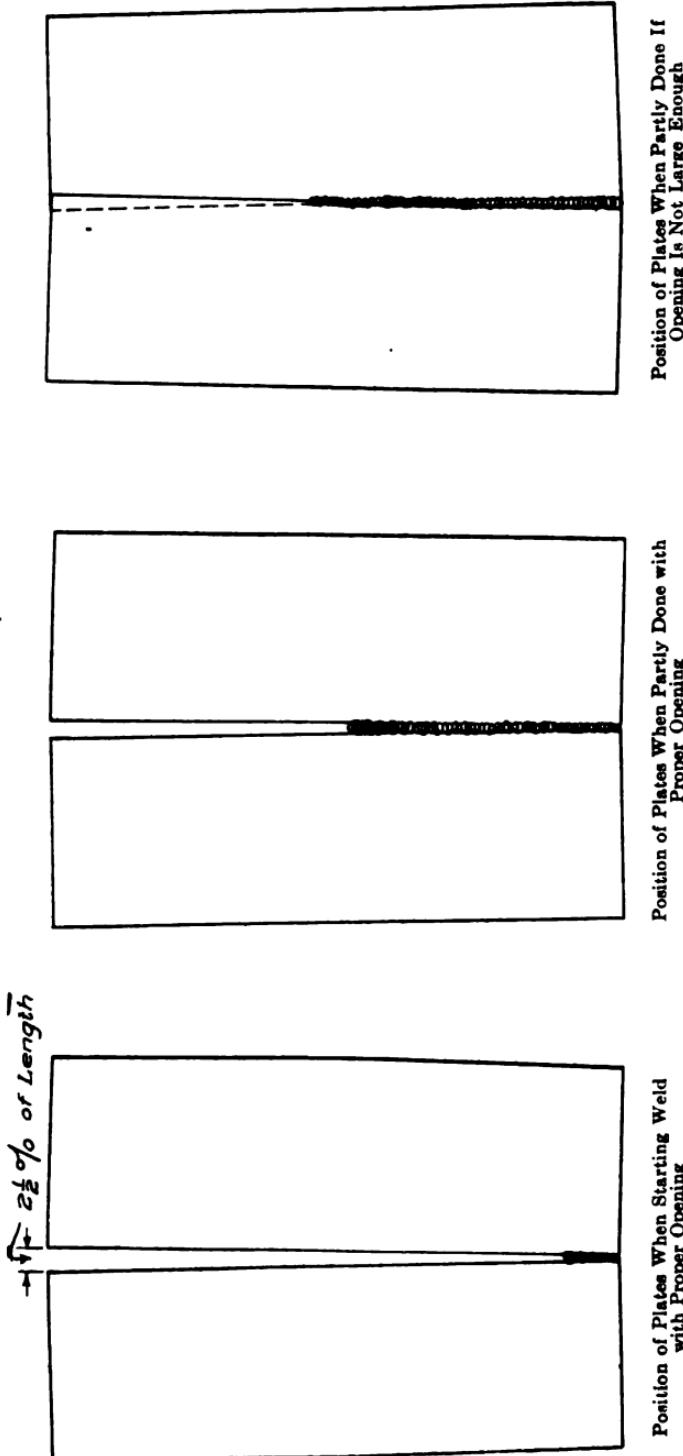
Cost of Cutting Jobs. When doing cutting with the electric arc, using a graphite electrode, work can be done at nearly one square inch of cross-section per minute for each 100 amperes used in the arc. Cutting with gas is much more rapid but is just about the same in cost on account of the great amount of oxygen used for this operation. Table VI gives the costs of gas cutting.

TABLE VI
Cost of Gas Cutting per Foot

THICKNESS OF STEEL (in.)	OXYGEN (cu. ft. per ft.)	ACETYLENE (cu. ft. per ft.)	TIME (min. per ft. cut)	TOTAL COST (per ft. cut)
$\frac{1}{8}$	0.45	0.12	1.00	1.25
$\frac{1}{4}$	0.50	0.13	1.00	1.35
$\frac{5}{16}$	0.60	0.13	1.00	1.5
$\frac{3}{8}$	0.90	0.18	1.25	2.1
$\frac{1}{2}$	1.30	0.19	1.25	2.7
$\frac{5}{8}$	2.50	0.25	2.38	4.6

Table VI is based on oxygen at \$1.50 per 100 cubic feet, labor at 35 cents per hour, and calcium carbide at $3\frac{1}{2}$ cents per pound, and is based on straight cutting. For complicated work it will cost more.

When welding long seams in sheets it is necessary to allow for the shrinkage of the filling material, and this should be done by spreading the edges of the sheets farther apart at the end to be welded last than at the starting place. In the sketch, Fig. 35, is shown the idea; the opening should be about $2\frac{1}{2}$ per cent of the length of the seam. When welding with gas the work should progress away from the operator, and when using the arc it is better to work toward the operator. The welding rod must touch the work when welding with gas, whereas it must be kept away from contact with the work when using the metallic arc or the arc will go out and the rod stick to the job, but graphite work is done similar to gas weld-



ing. Gas welding should be done by giving the flame a rotary motion by moving the torch around over the work, but for metallic electrode work the hand should be held steady and progress straight along the seam. If blowholes appear on the surface of welds being made with the graphite arc or with gas, they can be filled in by fusing the metal down; but if bad spots appear when using the metallic electrode, they must be chipped out and re-welded. The metallic electrode is always depositing metal, but the graphite arc and the gas flame are always melting it. These and other points will soon be learned by the operator, but are mentioned here to emphasize them and forestall trouble as much as possible. As the operator gains in experience, he will see many other things it is not possible to cover here but which will be very valuable in his work.

CHEMICAL WELDING

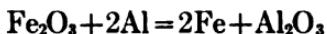
In the early part of this article, *chemical welding* was mentioned as the third form of welding. This is almost exclusively made use of by the Goldschmidt Thermit Company of New York City. While, as before stated, this method is generally confined to large subjects such as immense crank shafts, cast-iron lathe beds, etc., yet it is not out of place to give here a very brief treatment to this form of welding.

Thermit Welding. Welding by the thermit process is really "cast welding", because it is accomplished by pouring "thermit steel" around the parts to be joined. The main difference between this and other methods of cast welding lies in the method of producing the molten metal. The name for the process is derived from the Greek word *therme*, meaning "heat", and signifies that it is a heat process of welding or that the metal is produced by heat. The name was originally adopted as a sort of trade-mark but has come to be accepted as the name of the process.

Chemical Reactions in Thermit Welding. The thermit welding process is based upon a long series of experiments carried on for a number of years by various physicists and metallurgists to find some method of reducing metals readily from their oxides and ores. It is the direct result of the work done by Dr. Goldschmidt of Essen, Germany, in what is now the new field of aluminothermics, and is based on his discovery that if finely divided metallic oxides

are mixed in certain proportions with finely divided aluminum they will, if ignited, fuse and produce a temperature of 5400 degrees Fahrenheit in less than 30 seconds without the use of heat or power from the outside. The high affinity of aluminum for oxygen will cause it to draw the oxygen from the metallic oxide, combine with it to form aluminum oxide, raise the temperature of the mass by the violent reaction, and set the metal free. The greater weight of the metal will cause it to flow down through the mass in the container and the aluminum slag will rise to the top.

For ordinary commercial welding purposes in machine shops and foundries, iron oxide is used and the reaction takes place according to the equation



The liquid steel produced by this process represents one-third of the original material by volume and one-half of the original mixture by weight, the balance being lost as slag. This method of cast welding was developed about the year 1900, and the peculiar reaction used has also been applied to the production of numerous kinds of alloys and metals free from carbon. Further reference will be made to this.

Analysis of the Composition of Thermit Steel. According to data furnished by the makers of thermit-welding apparatus the average analysis of thermit steel is as follows:

Carbon.....	0.05 to 0.10
Manganese.....	0.08 to 0.10
Silicon.....	0.09 to 0.20
Sulphur.....	0.03 to 0.04
Phosphorus.....	0.04 to 0.05
Aluminum.....	0.07 to 0.18
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	0.36 to 0.67

The balance of the mixture is iron.

Method of Starting the Reaction. During the experiments leading to the development of thermit welding, the mixture of metallic oxide and aluminum was heated from the outside to start the reaction, but finely divided aluminum will not melt at the temperature of cast iron and it was necessary to heat the mass so high that when action started it resulted in an explosion. So Dr. Goldschmidt used

a storm match to ignite a fuse of barium peroxide (BaO), which in turn ignited the mixture and started the reaction.

Equipment for the Process. The apparatus required for thermit welding consists of a crucible, tripod, pre-heater, yellow wax, and a spade, with which there must also be used perishable materials consisting of thermit, manganese, molding material, and ignition powder. The shell of the crucible is of sheet iron and it is lined with magnesia in order to stand the high temperature and has a magnesia stone thimble at the bottom through which the metal flows. The process of preparing the lining is rather elaborate and must be carefully done or the life of the crucible will be greatly reduced. The tripod is used to support the crucible above the work, and the pre-

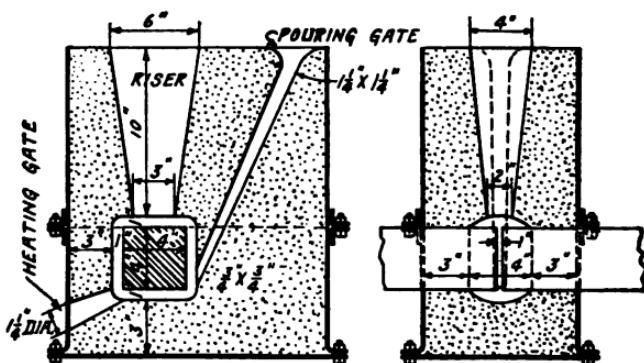


Fig. 36. Section of Typical Thermit Mold Showing Riser, Pouring Gate, and Heating Gate
Courtesy of Goldschmidt Thermit Company

heater is a combination compressed air and gasoline outfit used to heat the article to be welded in order that it may not chill the filling material. The wax is for forming the space to be filled when welding and about which a mold is made. It is melted out of the mold before welding.

Preparing the Mold. The process of preparing the crucible and the mold are the principal features of the entire operation of thermit welding, as the mere act of casting the weld is comparatively simple. The crucible is a sheet-iron shell with a hole below for the metal to pass through. It is to be lined with magnesia carefully packed while hot enough to be plastic, and with a magnesia stone thimble at the bottom to form a bushed hole and protect

the crucible. The magnesia lining should be put into place slowly and carefully and tamped tightly into place, for its value depends largely upon how hard it is packed. The lining is formed around a matrix to shape the hopper-like center and must be baked at a dull red heat for six hours before it is ready to use. A crucible will withstand about 20 reactions if well made, and must then be relined. The thimble must be placed in the bottom of the crucible so as to be removable.

Construction of Mold. The construction of the mold is really the most important part of the operation, because upon this depends the amount and application of the filling material. The container or flask is usually made of steel plates placed so as to form a box around the part to be welded, and then filled with the clay, etc., of the mold, the plates being fastened with bolts, tie-rods, clips, or clamps of whatever sort may be available, Fig. 36. The first step in the formation of the mold is to build a collar of the yellow beeswax around the place to be welded, making this of the size and shape desired for the weld. After the collar is formed, the flask is placed around it and filled with a mixture of ground fire brick, fire clay, and fire sand in equal parts. There must be three channels in every mold, a pouring gate, a riser, and a heating gate. The pouring gate should run from the top of the mold down to the bottom of the wax collar to insure the metal filling the mold and to allow the good steel to reach the weld instead of being crowded out by the slag. The riser should be immediately above the wax collar, if possible, so that the slag and surplus metal can rise freely from the metal of the weld, and the heating gate should run from one side of the mold into the bottom of the collar in order that the wax can all run out of the mold when melted by the pre-heating torch. As soon as the mold is completed, the torch is applied and the wax melted out. The flame is allowed to play into the mold until it is entirely dry and then the heating gate must be plugged with clay to stop it up entirely. Fig. 37 shows a typical thermit weld, with pouring gate and riser still attached.

Thermit Required for Given Weld. The amount of thermit required to make a given weld will be twice the amount necessary to fill the space formed by the wax collar, because one-half of the weight of the original powder will rise in the form of aluminum slag,

as already stated. On the other hand, the cubical area of riser and gate must be twice as great as the collar because the volume of the slag will be two-thirds of the total volume of the casting. It has been determined by experience that the weight of thermit necessary for a given job will be 32 times the weight of the wax required to form the collar for the mold; so the wax should be weighed after melting out of the mold in order to know how much thermit is required for the job. The size and shape of the mold and riser and gate will vary somewhat for different jobs and the relation between



Fig. 37. Typical Thermit Weld Showing Riser and Pouring Gate Casting Still Attached
Courtesy of Goldschmidt Thermit Company,
New York City

weight of wax and mixture will vary accordingly, but the ratio of 32 to 1 is a good average. It is necessary to pre-heat the article at the joint until it is red-hot before starting to pour the metal, and this is done with the gasoline torch through the heating gate at the bottom of the mold before plugging it.

Addition of Other Materials. When more than 10 pounds of thermit are required for the weld, it is necessary to moderate the heat of the reaction slightly, and this is done by adding small pieces of clean steel to the powder. These may be punchings, rivets, or any other soft steel pieces but must be free from grease to keep

carbon out of the mixture, and from 10 to 15 per cent of the weight of the thermit may be added in this way. About 2 per cent of pure metallic manganese should also be added in order to increase the strength of the weld. If the manganese is not obtainable, 3 per cent of ferromanganese may be added instead, although it increases the violence of the reaction and hardens the metal.

Applications of Thermit Welding. The applications of thermit welding are numerous, although the process is better suited to large



Fig. 38. Broken Stern Post of Boat Welded by Thermit Process
Courtesy of Goldschmidt Thermit Company, New York City

jobs where the saving in cost of new pieces will justify the cost of the work. It will be evident also that the process lends itself better to welding large articles than small ones and experience up to the present shows that most thermit welding has been done on such large articles as engine and machine tool frames, locomotive side frames, and motor cases. Another application is the repair of stern and rudder posts of vessels, Fig. 38. The widest application seems to be in steam railroad shops and, while it is true that the electric

arc-welding process is rapidly superseding all others for that service, some of the work done is worthy of description. Considerable saving has been made by doing the work without dismantling the engines in order to get at the break. The process is to form the mold about the break, as described, and set the crucible above it ready for pouring. Where it is possible to lay the article on the floor, as when welding crank shafts or a broken link, the job is much easier and quicker to perform.

If the brake is in the upper part of a locomotive frame, for example, the break should be cut out about an inch and the frame jacked apart another quarter of an inch. The inch space is for filling and the $\frac{1}{4}$ inch is to allow for shrinkage; so the jacks should be removed as soon as the mold is filled. Breaks in other parts of locomotive frames are treated in the same way. For welding driving-wheel spokes, it is best to heat the adjacent spokes with a torch to expand them before welding the broken ones, and then allow them all to cool at once. Rail welding for street railways is another application of thermit. In all cases it is necessary to clean the metal thoroughly around the joint to remove grease and scale, and this is best done with a sand blast so as to insure bright clean metal to fill against. For work of this nature it pays to provide the fullest equipment in order that there may be no failures, because it is a very expensive operation and very hard to do over again.



might be entailed by letting them go for want of prompt attention. The monthly or weekly charge for rent is eliminated, the car is kept better, upkeep and maintenance charges are reduced to a minimum, and other material savings are effected. The private garage, then, places an automobile within reach of a large number of persons.

Many persons have a barn or other outhouse which seems so nearly suitable that a few dollars would convert it into a usable garage. Experience has proved that this will seldom turn out as



Fig. 2. Enhancing the Beauty of the Garage with a Connecting Pergola

satisfactorily as the specially constructed building, some later developments showing where the garage would have been more economical or better suited to the work in the long run.

Types. Having decided to build, the next point to settle is the form and the construction material. As far as the latter is concerned, there are about eight possibilities, as follows: (1) wood; (2) steel; (3) wood and steel; (4) concrete; (5) hollow tile; (6) other fireproof types; (7) concrete in combination with any or all of these, as wood, steel, or tile frame with concrete finish and floors; (8) brick or stone, either alone or in combination.



Fig. 3. All-Wood Garage with Living Accommodations for Chauffeur



Fig. 4. Hollow Tile and Cement Garage

Doubtless the majority of garages to be considered will come under Figs. 1, 5, 8, or 9, but they all represent rather distinct types. For instance, Fig. 1 has a sheet metal (metal lath on steel angles) framework with a smooth concrete plaster covering, while the floor and runway are of cement, and the roof of shingles on wood framing. This represents the semi-fireproof type, walls and floor being strictly fireproof, while doors, window frames, and roof would burn readily. As such, the insurance rates would be much higher than on an all-concrete structure. In Fig. 2 is shown a brick garage connected to the residence by a pergola. In Fig. 3 is shown a garage



Fig. 5. Artistic Brick and Stone Garage

which is all wood except for the floor and runway, the latter extending the full width of the building in front. The forward portion of the garage is carried up a second story for the chauffeur and his family. The building houses three large cars and is well equipped.

An example of hollow tile construction with a thin cement plaster covering is shown in Fig. 4. This holds two cars and provides living rooms on the second floor, similar to Fig. 3. Except for window frames, doors, stairs, and roof, this is fireproof, the hollow tile giving the additional benefit of greater warmth in winter and coolness in summer. As will be shown presently, this material may be used without an interior covering.

A few other types will be discussed briefly. Fig. 5 shows a brick building with very ornamental stone trimmings. This garage



Fig. 6. All-Frame Garage for Two Cars



Fig. 7. Pretentious Concrete Garage with Tiled Roof

will house two or three cars and is provided with double doors to facilitate entrance and exit, always an important feature. Fig. 6



Fig. 8. Frame Garage with Plaster Second Story.

represents an all-frame structure, and Fig. 7 one of concrete with a tiled roof and holding three cars. Of all the types so far shown, this



Fig. 9. Fireproof Garage with Concrete Foundation.



Fig. 10. Excellent Garage of Concrete and English Half Timbering



Fig. 11. Concrete Garage in Pretty Setting



Fig. 12. Concrete Block Garage



Fig. 13. Brick and Concrete Garage of Artistic Design

any shown. Fig. 11 is of concrete, Fig. 12 is of the same material in block form, while Fig. 13 has a brick first floor and stucco plaster over wood for the second, and Fig. 2 is all brick.

Concrete being considered the best material for garage construction, a few words in detail will not be out of place. Concrete may be used either as a plaster over steel or other structure, the thickness of this layer varying with conditions from 1 inch up to 3, or it may be moulded in forms and allowed to set, in the latter case the thickness required being as high as 18 inches.

When used in forms, as many of the latter must be built as the workmen can fill with semi-liquid concrete at one time. Fig. 14 gives the details of such a form, one end being left open to show the foundation and wall thicknesses. Smooth boards must be used, otherwise the resulting wall will be rough.

When metal lath is used on a structural iron framework, Fig. 15, the concrete is laid on like plaster. The illustration shows what can be done for less than \$200 including the contractor's profit, the cost of each individual item being given below. The floor plans and arrangement will be presented and discussed later.

Cost of a One-Car Concrete-on-Metal-Lath Garage

568 sq. ft. of No. 24 gauge lath at 6 cents per foot.....	\$34.00
535 pounds of structural steel at 5 cents per pound, ready for erection.....	26.75
3 windows, with 12×20 glass 1 light high, 5 wide.....	14.00
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Total materials cost.....	\$74.75
Floor 3 inches concrete, 1 inch finish.....	\$16.80
Erection of structural steel and Hy-Rib, labor only.....	15.00
Wall plastering, 2 inches thick, roof 2½ inches.....	65.00
Door, 1½ inches thick, including hanging and hardware.....	20.40
Glass and glazing	2.80
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Total work and accessories cost.....	\$120.00
Grand total of entire building, including contractor's profit..	\$194.75

The interior of the hollow tile garage, which is shown complete in Fig. 4, is brought out in Fig. 16, the wall surface being formed by the tile themselves, without the aid of plaster. In the foreground may be seen the drain, while just above it will be noted the washer and the electric lights. This building shows an important advan-



Fig. 16. Interior of Fig. 4. Showing Plain Tile Finish



Fig. 17. Convenient Back-Lot Garage of Simple Construction

tage in garage construction, namely, the superior utility of length as compared with width.

One-Car Designs in Detail. *Long Type.* The majority of garages are of the one-car type, although occasionally it happens that neighbors get together and build a common structure, or else one man builds large enough for three or four, and rents space to his neighbors. Fig. 17 shows what may be done with the back of an ordinary suburban lot. Here a small garage of wood has been erected at the extreme rear, with a washing platform and runways

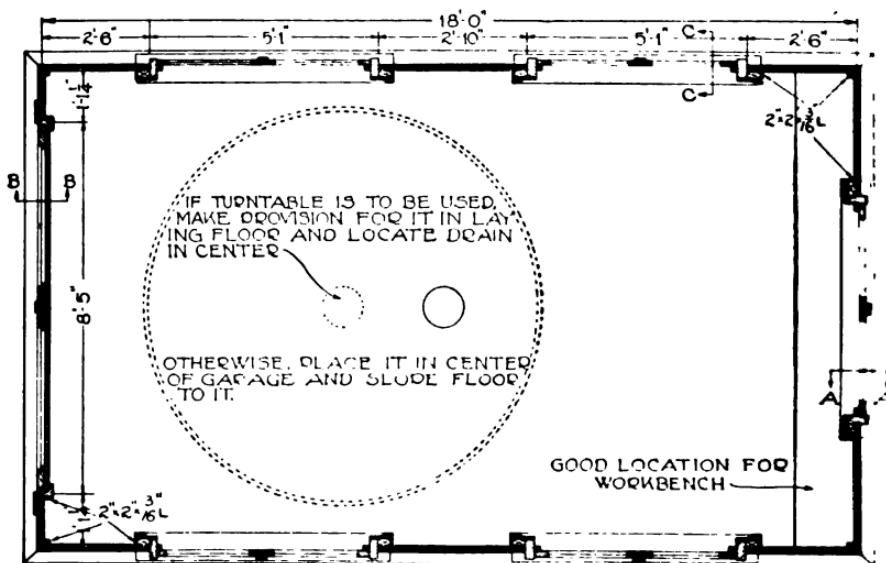


Fig. 18. Floor Plan of a Garage Showing Turntable

of cement, the whole being surrounded in a pleasing manner by vines and trees. While the building is not large it saves the owner many a long walk to and from the nearest public garage as well as considerable money in the course of a year.

It will be noted that its size will allow only room for the car and for a passageway 2 feet wide on each side. Such a scant amount of space is seldom advisable if the owner figures on doing his own work, in which case the design should include a well-located workbench and a full stock of tools. The floor plan shown in Fig. 18 really represents the plan of Fig. 9 and of Fig. 15 slightly modified. In this drawing the writer has included an extra window on each of the

long sides, making this change because of the large number of garages he has seen which were planned with too little light. As a matter of fact, when the car is in the building and is blocking off the big double doors at the front, and usually the one side window also, some unobstructed window light is absolutely necessary.

A workbench has been included at the rear end, with a large window over its middle, and a turntable near the center of the floor. The floor space of this garage is sufficient to allow turning a car, so that it may be driven in front end first, and then turned around so as



Fig. 19. Square Type of Garage of Concrete Construction

to leave in the same manner. The frequent accidents caused by backing out or into the building are thus avoided, and washing and repair work are made much easier.

Square Type. The neat little concrete garage shown in Fig. 19 is more nearly square in shape than those already shown. This brings up the question whether the square or the long type of equivalent area is preferable. Some hold that the short, nearly square shape presents the most advantages, since everything is close together; others believe that the long, narrow shape has many advantages over the square form.

For this reason two sketches of typical floor layouts, Figs. 20 and 21, have been prepared. The former measures 17×18 feet,

and its inside area about 283 square feet, while the latter, measuring 14×22 feet 6 inches, has about 295 square feet of floor area inside, a difference of about 4 per cent. At a glance the longer one shows more working space, although, to be perfectly fair to the square type on this point, the turntable in Fig. 20 should be as close to the front door as in Fig. 21.

As to window space the two types are about equal, the extra back window and the two small front windows in the square

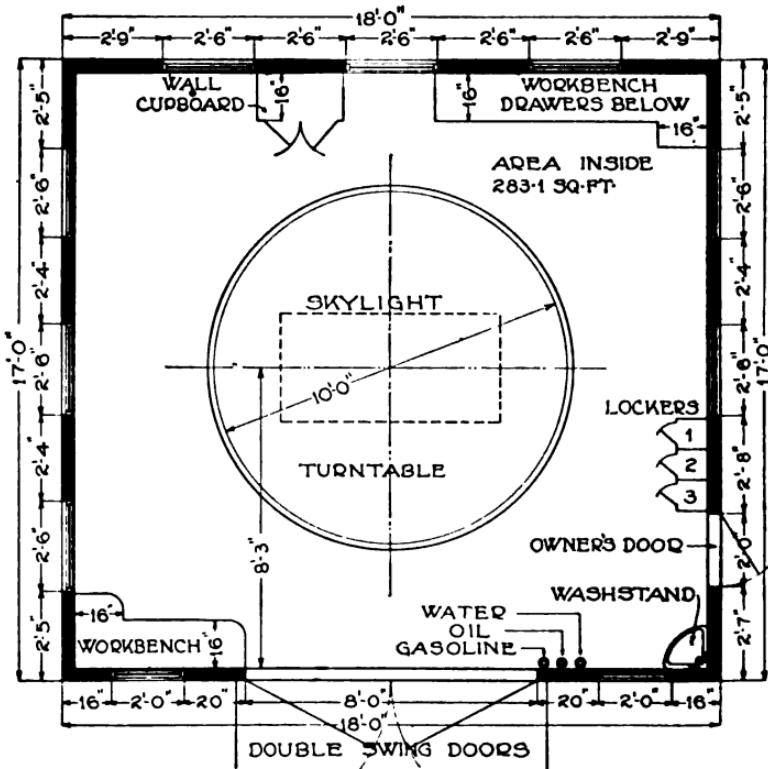


Fig. 20. Floor Plan of Square Type of Garage

type being offset by the larger number of windows which can be used on the sides of the long type. When working on a dismantled car, however, for occasional repairs or during the spring and fall over-haul, the design of Fig. 21 gives more open area at the back, clearer bench room, and freer window space.

Portable Form. It would not be quite fair to dismiss the one-car garages without mention of the portable form. This type, an

excellent specimen of which is shown in Fig. 22, has the attractive feature to the busy man of being sold ready for use by its makers. The one shown is 12×18 feet inside, and is made in sections. To the man who does not own his home, it solves one highly important point—that of the disposition of his building should he move. A portable garage is simply dismantled and erected at the new quarters, none the worse for the change.

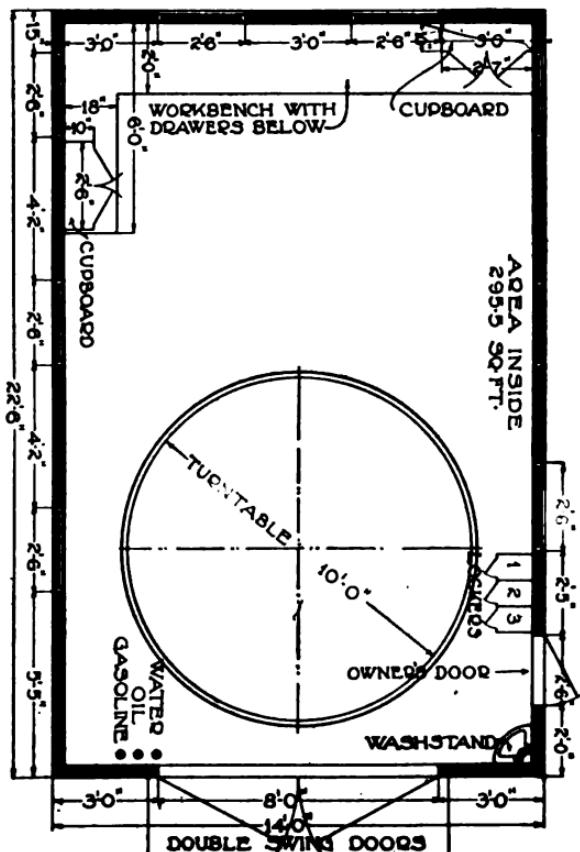


Fig. 21. Floor Plan of Long Type of Garage

Two- and Three-Car Designs. Turning next to the garages which are built primarily for two or more cars, and which in the main are more commodious and better appointed throughout, there enters for the first time the consideration of the quarters for the driver and his family. Sometimes, although the construction of the building may be very elaborate, the element of convenience and

adaptability has often been ignored entirely. Such, for instance, is the garage shown in Fig. 23, the plans for which may be seen in Fig. 24. The building is two stories high, the second being given over to living rooms entirely. Even on the first floor, the coal storage, furnace, storeroom, entry, stairs, and charging room for batteries take up more than one quarter, so that, of the total area, the cars have less than three eighths. In considering this design, it will be noted that aside from the double front doors, there is little provision for light. The car room, measuring 25×30 feet—that is, 750 square feet—has only four windows, all small and all at one end. The rear of this



Fig. 22. Portable Type of Garage

room has no windows, nor has the repair room, with its pit, any light except when the doors to the store and charging rooms are left open. A better arrangement could have been effected by placing the coal and charging rooms in the center and the repair room with pit on the corner.

Almost as bad in this respect is the English garage, Fig. 25, where three tiny end windows, over 40 feet apart, and as many skylights some 20 feet in the air, are depended upon to illuminate the whole interior of a building measuring 30×46 feet. This garage has steel roller blinds for the entering doors, so that with these closed no light can be expected from that side as might be the case with wood paneled and glass forms.

An improvement over both may be seen in Fig. 26 which is of field-stone construction. Although it houses but two cars, it is



Fig. 23. Example of Pretentious Private Garage with Bad Interior Design

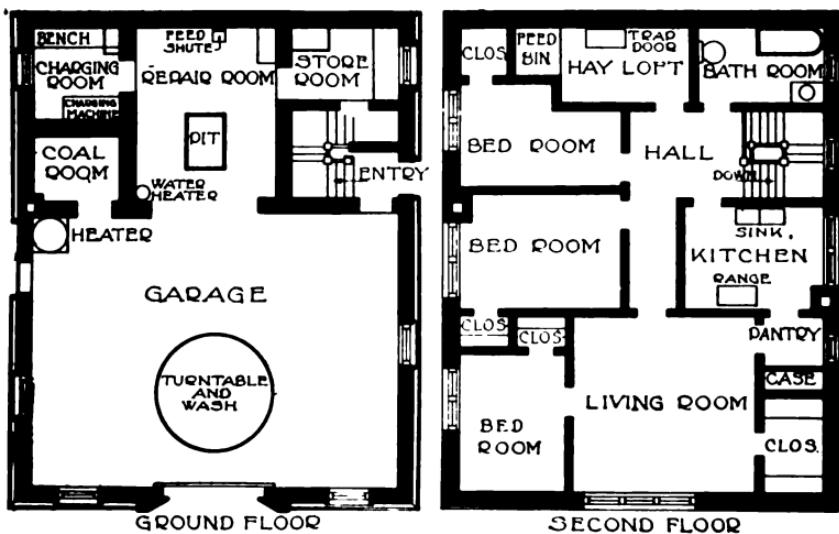


Fig. 24. Floor Plans of Garage Shown in Fig. 23

sufficiently large for three, having interior dimensions of 20×30 feet. The interior has a wash stand and lockers at the entrance on the right. At the back, on the same side, are a forge, anvil, drill press,

and other tools. In the middle of the rear side is a large fireplace, while the entire left side is taken up with a wide workbench which

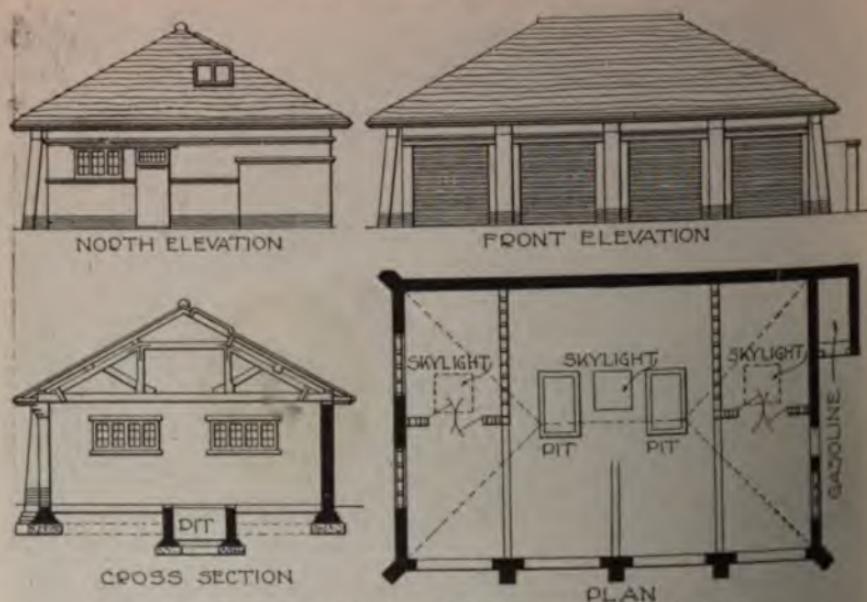


Fig. 25. English Garage with Inadequate Lighting Facilities



Fig. 26. Stone Garage of Good Construction

runs from front to rear. The doors are double, each half folding up into three sections. When all are folded back, practically the

shown in Fig. 27 has the advantage of bringing the car close to heating plant, so that the usual heating problem is much simplified while having the car inside the house, so to speak, makes for economy of the owner's time in coming in and going out, in doing work on the car, and otherwise.

Along similar lines but of a different nature is the garage and boathouse combination shown in Fig. 28. This is located at the foot of a hill at the top of which is the owner's house. This apparently unfavorable location turns out to be very desirable because



Fig. 28. Combination of Garage and Motorboat House, Along the Same Lines as the Basement Garage, Fig. 27

is at the water's edge. In this position, the part on the water extends down low enough to form an admirable place for the motor boat, thus housing the two motors, car and boat, in the one building. An inside stairway makes communication easy, while the majority of the windows are on the water side. Unfortunately the picture was taken at low tide, so that very little water is visible.

GARAGE EQUIPMENT

General Equipment. In the planning of the general equipment of a garage considerable stress should be laid upon lighting, heating, ventilation, water supply, drainage, and similar items.